# AN2406
# RTD/Thermistor
# Monitor/Controller
# User's Manual

MP MASTER
MA29920

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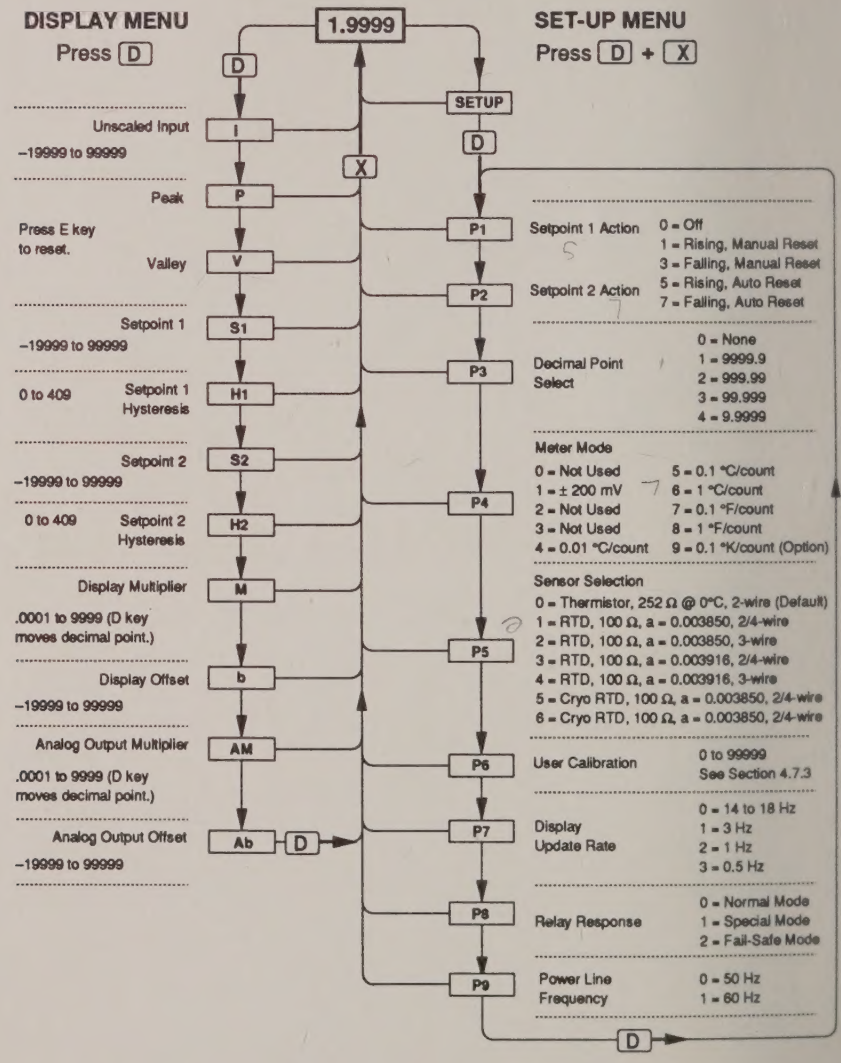
## NORMAL DISPLAY MODE




| | | |
|---|---|---|
| D **MENU SCROLLING** Press to Select, Release to Read | ► **SELECT DIGIT** | E **ENTER VALUE** and return to Normal Display Mode |
| A **RESET ALARMS (RELAYS)** | ▲ **INCREMENT DIGIT** | X **EXIT MENU:** and return to Normal Display Mode |

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Revision 0
April 1992

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# HOW TO USE THIS MANUAL

This manual contains operating information for the Champion Series Model AN2406 panel meter.

The information is organized into the following sections:

| | |
|---|---|
| 1 INTRODUCTION | Introduces you to the AN2406 RTD/Thermistor panel meter and its options. |
| 2 INSTALLATION | Installation instructions for the basic meter. Describes jumper selections, signal connections and special factory options. |
| 3 INSTALLING OPTIONS | Installation instructions for all options available for the AN2406. |
| 4 OPERATING INSTRUCTIONS | Explains the front panel controls and indicators and how to access all functions of the AN2406. |
| 5 PRINCIPLES OF OPERATION | Functional description of the AN2406. |
| 6 SERVICE AND SUPPORT | Contains a troubleshooting guide and information on obtaining service and technical support. |

APPENDICES:

- A Specifications
- B Ordering Information
- C Mechanical Drawing
- D Reference

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# 1 INTRODUCTION

## 1.1 THE AN2406 RTD/THERMISTOR METER

The Champion Series instruments, commonly known as digital panel meters, are a family of process monitor/control instruments designed for custom OEM requirements and standard applications of process signal conditioning, measurement and control.

The Model AN2406 is a 5-digit RTD and Thermistor meter as determined by user-selectable jumpers and user-programmable setup parameters. The AN2406 measures temperature signals and displays the value in degrees F (1 or 0.1 degrees/count) or C (1, 0.1 or 0.01 degrees/count). Be sure to read Section 2 before attempting to set up and operate your panel meter. See Section 3 for installing any separately-purchased options.

## 1.2 OPTIONS AND ACCESSORIES

The AN2406 can support the options described in Table 1-1. These options are installed in your panel meter by mounting an optional circuit board onto the meter's chassis. As an accessory, a backplane connector with screw terminals can be obtained to replace the standard solder terminal connector shipped with your unit. Options can be ordered separately or installed with your order at the factory. See Appendix B for ordering information.

**Table 1-1. AN2406 Options**

| Option | Description |
|---|---|
| Dual Relay Outputs | Microprocessor-controlled digital outputs provided by two form C relays. |
| Analog Output | A microprocessor-controlled analog output of 0 to 20 milliamperes or 0 to 10 volts, scalable by the user. |
| Serial Communication | Standard RS232 Serial Communications Interface |
| Excitation | An isolated 24-milliampere current source selectable at 24Vdc or 12 Vdc. |
| Front Panel Lockout | A jumper-selectable feature that enables or disables keyboard acess to the meter. |

When options are included with your order, the additional hardware is installed and set up at the factory for your application. The analog output and excitation options include output selection jumpers which may need to be changed to meet your requirements.

In addition to the options mentioned above, the AN2406 can be ordered with a Cryogenic RTD Range or a temperature scale in 0.1 °K. Either of these are installed only at the factory.

## 1.3 HARDWARE DESCRIPTION

The AN2406 panel meter is enclosed in a black, ABS plastic case (see Figure 1-1). The internal circuit board and display panel comprise an integrated assembly which slides into the case from the front. All power and signal connections are made through the standard rear-panel edge connector or optional backplane connector. AN2406 panel meters can be ordered to operate on 110/220 volts ac or 8 to 28 volts dc.

**CAUTION**

The panel meter is held in the case by being plugged into the rear-panel connector. Before detaching the rear connector from the case, remove the meter from the case first. Failure to do this may cause the panel meter to fall out of the case and suffer damage.

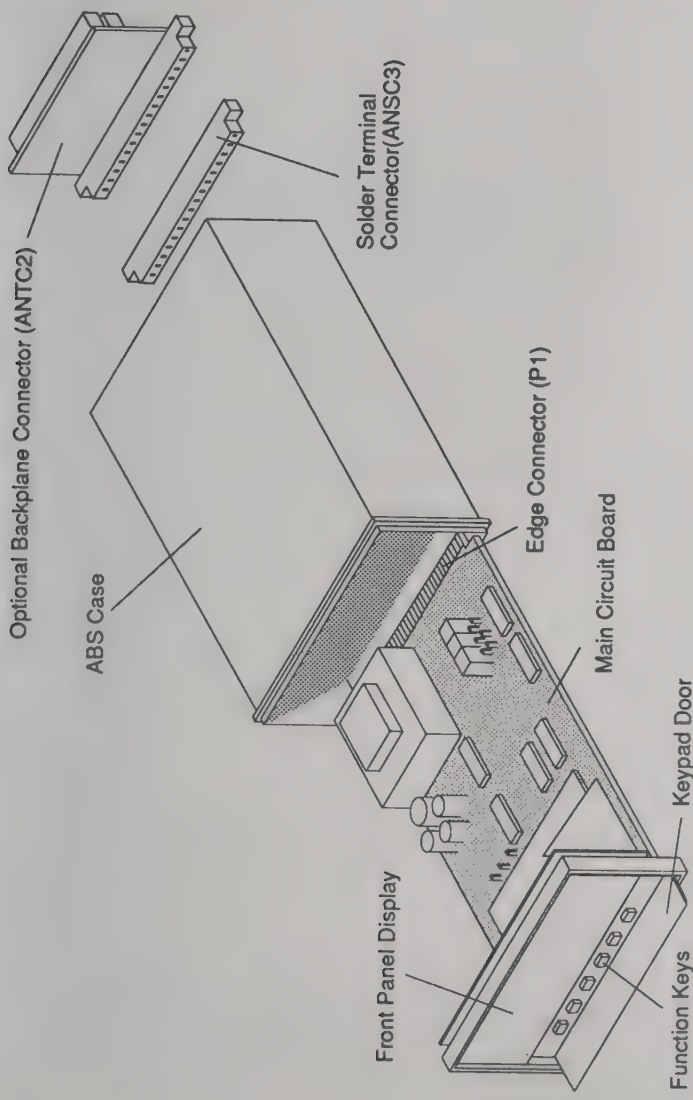



Figure 1-1. Basic Hardware Configuration

# 2 INSTALLATION

## 2.1 INTRODUCTION

This section includes unpacking, installation and set-up information for the AN2406. Before you begin operating the AN2406 it must be set up properly for your application. This section describes how to mount the meter in a panel, set up input jumpers for RTD or thermistor, and install power and signal wiring. Installation instructions for separately-purchased options are given in Section 3.

To install the AN2406, follow these basic steps:

(1) Unpack the panel meter (Section 2.2).

(2) Remove the meter from its case (Section 2.4)

(3) Set up input jumpers for RTD or Thermistor (Section 2.5).

(4) Install any separately-purchased option boards according to the procedures given in Section 3.

(5) Mount the case (Section 2.7).

(6) Connect power wiring (Section 2.8).

(7) Connect input signal wiring (Section 2.9).

(8) Return the meter to the case (Section 2.4).

**CAUTION**

The panel meter is held in the case by being plugged into the rear-panel connector. Before detaching the rear connector from the case, remove the meter from the case first. Failure to do this may cause the panel meter to fall out of the case and suffer damage.

All Champion Series panel meters contain circuit devices which can be damaged by electrostatic discharge (ESD). Make sure you know how to properly handle electronic assemblies that contain ESD-sensitive components before removing the case of this instrument. See Section 2.3.

## 2.2 UNPACKING INSTRUCTIONS

After removing the panel meter from the shipping carton, inspect everything thoroughly for any visible damage. The following items are shipped with your order:

- Installation Manual
- Accessory Pack: 2 side clamps, 1 range label, 2 mounting screws and 2 jumper wires.
- Model AN2406 Panel Meter
- ANSC3 Standard Connector:

## 2.3 SPECIAL HARDWARE HANDLING REQUIREMENTS

The circuit boards in a panel meter contain ESD-sensitive devices. To avoid damaging these devices, we recommend that you use the following techniques whenever you handle the panel meter assembly after removing the case.

(1) Wear a grounded wrist strap before removing the electronic assembly from the plastic case.

(2) Temporarily store the electronic assembly in an anti-static bag or container while mounting the case.

(3) If you need to change any jumper selections on the board, always work on a grounded work surface and wear a grounded wrist strap.

(4) Always use grounded tools on the instrument. Hand tools are grounded when held by someone wearing a grounded wrist strap, unless the tool has insulated handles.

## 2.4 SEPARATING THE METER AND THE CASE

The case must be removed in order to install any separately-purchased options and to mount the case in a panel. When the instrument is in its case, the main circuit board is plugged into an edge connector mounted at the rear of the instrument. Due to this connection there will be some resistance when removing the instrument chassis from the case.

To remove the panel meter chassis from the case, open the keypad door as shown in Figure 2-1. Grasping the door with your hand, pull gently to remove the instrument from the rear connector and slide the panel meter chassis out of the case.

To return the panel meter to its case, align the main board with the lower slots on the inside walls of the case. If the unit has an option, align the option board with the upper slots on the inside walls of the case. Insert the circuit board(s) into the slots and slide the panel meter chassis into the case. Gently push the unit in until the bezel seats against the front of the case. This insures that the meter's rear edge connector is properly seated into the connector mounted on the rear panel of the case.

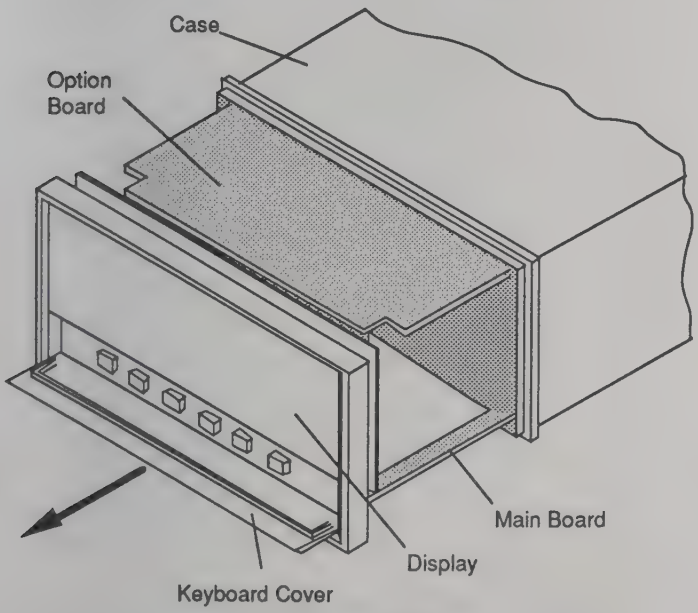



**Figure 2-1. Case Removal**

## 2.5 RTD/THERMISTOR SET-UP

The AN2406 can be set up for either an RTD or thermistor input. Figure 2-2 shows the jumper positions on the main circuit board for each type of input. To change the input range selection, remove the meter from its case and change the position of jumpers J3 and J5 according to the diagram. Then, slide the meter back into its case and gently push it back until it is firmly seated in the rear panel connector.

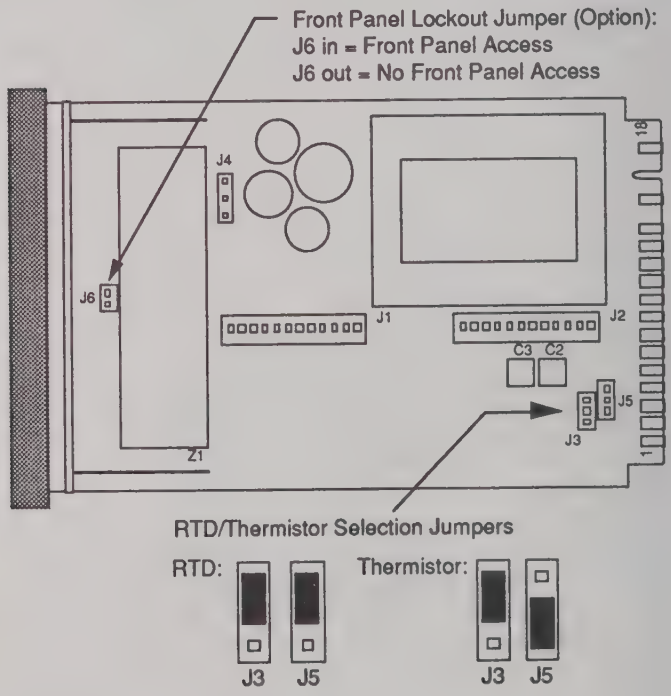
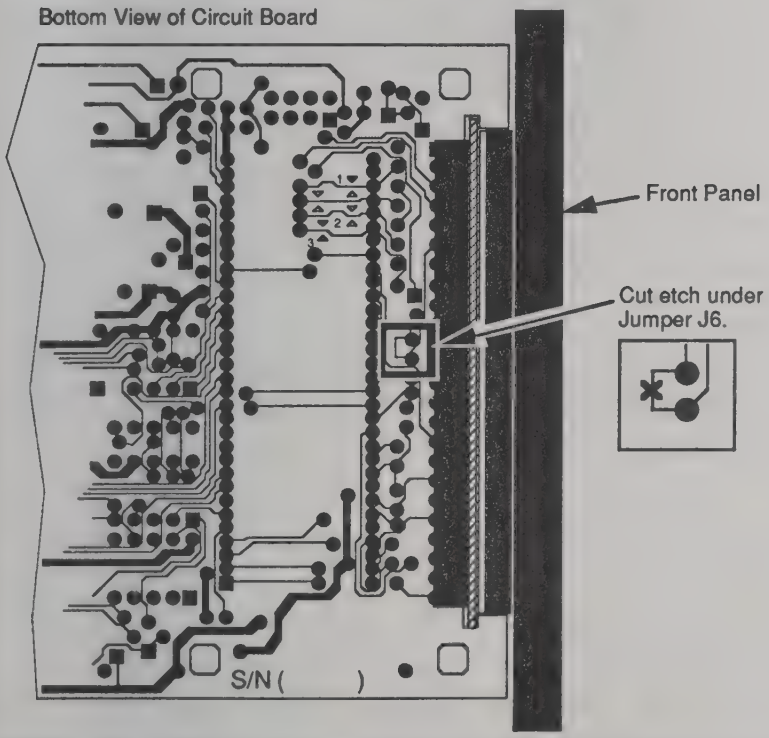



**Figure 2-2. AN2406 Hardware Set-Up Diagram**

## 2.6 FRONT PANEL LOCKOUT

Front Panel Lockout is an optional jumper-selectable feature that can enable or disable keyboard access to the meter. To use this feature, a printed circuit etch must be cut on the bottom side of the main circuit board. See Figure 2-3 for the location of the cut. After the etch is cut, install a jumper at J6 (See Figure 2-2) for keypad access or remove J6 for front panel lockout. Note that J6 must be installed to ensure the proper operation of command UL (Section 4.11).




**NOTE:** This modification must be performed by qualified service personnel only.

**Figure 2-3. Front Panel Lockout Hardware Modification**

## 2.7 MOUNTING THE CASE

Mounting instructions for the case are provided below. If you have any separately-purchased options, they should be installed before returning the instrument to its case after it is mounted. Figure 2-4 shows how the case is mounted in a panel. The overall physical dimensions of a cased panel meter is provided in Appendix C to help you plan for panel mounting. Note that two length dimensions are given, one for the ANSC3 solder-terminal connector and one for the optional ANTC2 backplane-type connectors.

To mount the case on a panel:

(1) Make a standard 1/8 DIN panel cutout [45mm (1.77in) x 92mm (3.62in)] for the AN2406 case.

(2) Remove the AN2406 from its case. See Section 2.4

(3) From the front of the panel, insert the case into the panel cutout and hold in place.

(4) Insert the mounting brackets into the side grooves of the case and slide the brackets forward until they press against the rear surface of the panel.

(5) Insert the two bracket screws into the holes at the rear of the mounting brackets and carefully turn them into the case.

(6) See Sections 2.8 and 2.9 for power and signal wiring information.

(7) Return the AN2406 chassis to its case. See Section 2.4.

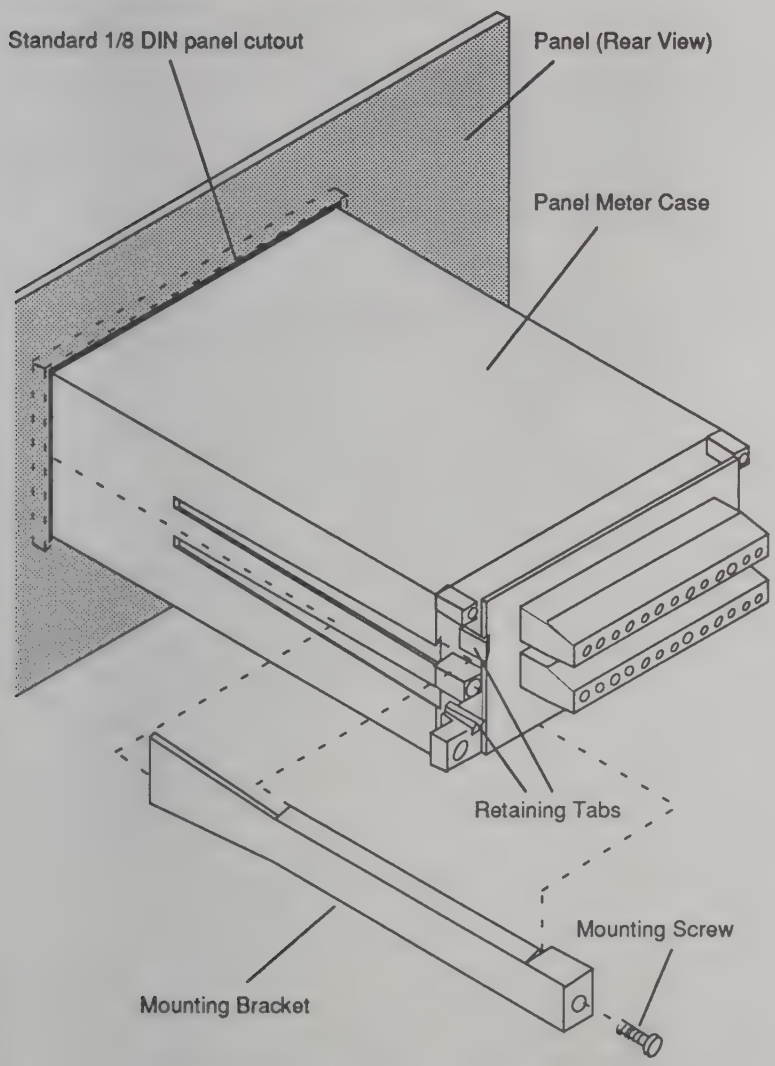



**Figure 2-4. Panel Mounting Diagram**

## 2.8 AC/DC POWER CONNECTIONS

A panel meter can be ordered to operate from ac or dc input power. AC units can configured for 110 (93.5 to 132 Vac) or 220 (187 to 264 Vac) volts ac. DC units operate on 8 to 28 volts dc. Power connections for the standard edge connector (ANSC3) are shown in Figure 2-5. Section 2.10 describes power connections for the optional backplane connector. The accessory pack includes two jumper wires for making power wiring connections.

**CAUTION**

Make sure you know the power configuration of your meter before applying power. Applying 220 Vac to a meter configured for 110 Vac will damage the meter. Applying 110/220 Vac to a dc-powered meter will also cause damage.

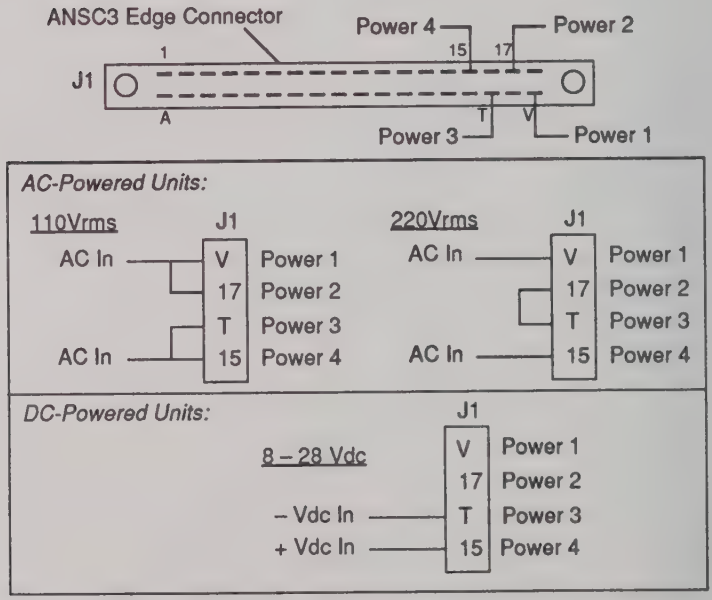



**Figure 2-5. Power Connections Using the ANSC3**

## 2.9 I/O SIGNAL CONNECTIONS

Figure 2-6 shows I/O signal connections for the AN2406 panel meter with the ANSC3 solder terminal connector. Figure 2-7 shows typical wiring connections for 2-wire, 3-wire and 4-wire devices. If you are using the optional ANTC2 backplane connectors, see Section 2.10 for signal connections.

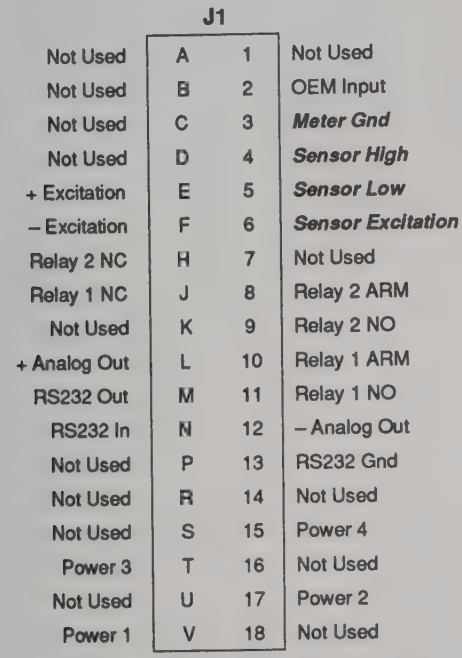
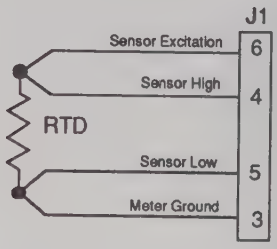
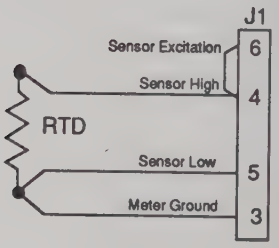

J1
Not Used A 1 Not Used
Not Used B 2 OEM Input
Not Used C 3 Meter Gnd
Not Used D 4 Sensor High
+ Excitation E 5 Sensor Low
– Excitation F 6 Sensor Excitation
Relay 2 NC H 7 Not Used
Relay 1 NC J 8 Relay 2 ARM
Not Used K 9 Relay 2 NO
+ Analog Out L 10 Relay 1 ARM
RS232 Out M 11 Relay 1 NO
RS232 In N 12 – Analog Out
Not Used P 13 RS232 Gnd
Not Used R 14 Not Used
Not Used S 15 Power 4
Power 3 T 16 Not Used
Not Used U 17 Power 2
Power 1 V 18 Not Used

**Figure 2-6. ANSC3 Signal Connections**

**4-Wire Input Connections**




**3-Wire Input Connections**




**2-Wire Input Connections**

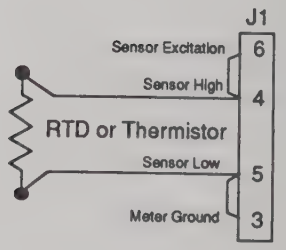



**Figure 2-7. Input Signal Wiring Configurations**

## 2.10 ANTC2 BACKPLANE CONNECTOR (OPTIONAL)

The Model ANTC2 Backplane Connector (Figure 2-8) provides screw-terminal connections for power and I/O signal wiring.

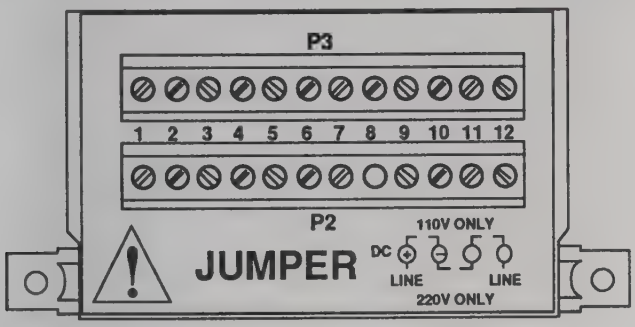



**Figure 2-8. ANTC2 Backplane Connector**

To install the ANTC2, use Figure 2-9 and the following procedure:

(1) Remove power from the meter.

(2) Using the keypad door as a handle, pull the meter out of the case.

(3) Remove the ANSC3 connector. Lift the two lower retaining tabs upward and pull the connector away from the case. Disconnect the existing wiring.

(4) Align the holes of the edge connector with the guide pins at the bottom corners of the rear panel and slide the connector onto the guide pins

(5) Push in gently on the connector until it snaps in place with the retaining clips. Gently push in on the top of the backplane until it snaps in place.

(6) Make the appropriate power and signal wiring connections for your particular panel meter. Refer to Figures 2-10 and 2-11.

(7) Return the panel meter to it's case.

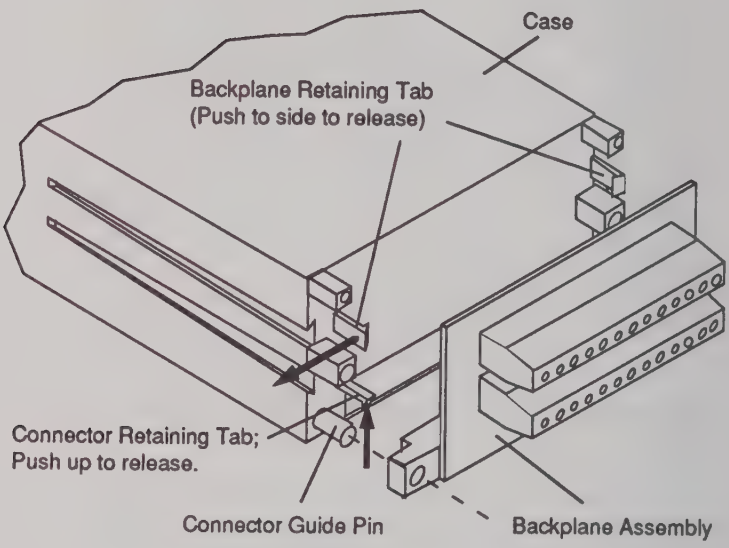



**Figure 2-9. Backplane Connector Installation Diagram**

**NOTE**

If the ANTC2 is used with a panel meter having a 12-pin J1 and an 8-pin J2 connector, or an ac-powered revision 2 or 5 main circuit board (P/N 11210), or a dc-powered revision 2 main circuit board (P/N 11247), the following changes apply:

P3-4 and P3-7 are disconnected.

P3-10 becomes "+ Excitation."

P3-12 becomes "– Excitation."

| | P2 | P3 | |
|---|---|---|---|
| ***Meter Gnd*** | 1 | 1 | OEM |
| Not Used | 2 | 2 | + Excitation |
| ***Sensor Low*** | 3 | 3 | – Excitation |
| ***Sensor High*** | 4 | 4 | Relay 2 NC |
| ***Sensor Excitation*** | 5 | 5 | Relay 2 ARM |
| + Analog Out | 6 | 6 | Relay 2 NO |
| – Analog Out | 7 | 7 | Relay 1 NC |
| Not Used | 8 | 8 | RELAY 1 ARM |
| Power 4 | 9 | 9 | Relay 1 NO |
| Power 3 | 10 | 10 | RS232 Output |
| Power 2 | 11 | 11 | RS232 Gnd |
| Power 1 | 12 | 12 | RS232 Input |

**Figure 2-10. ANTC2 Signal Connections**

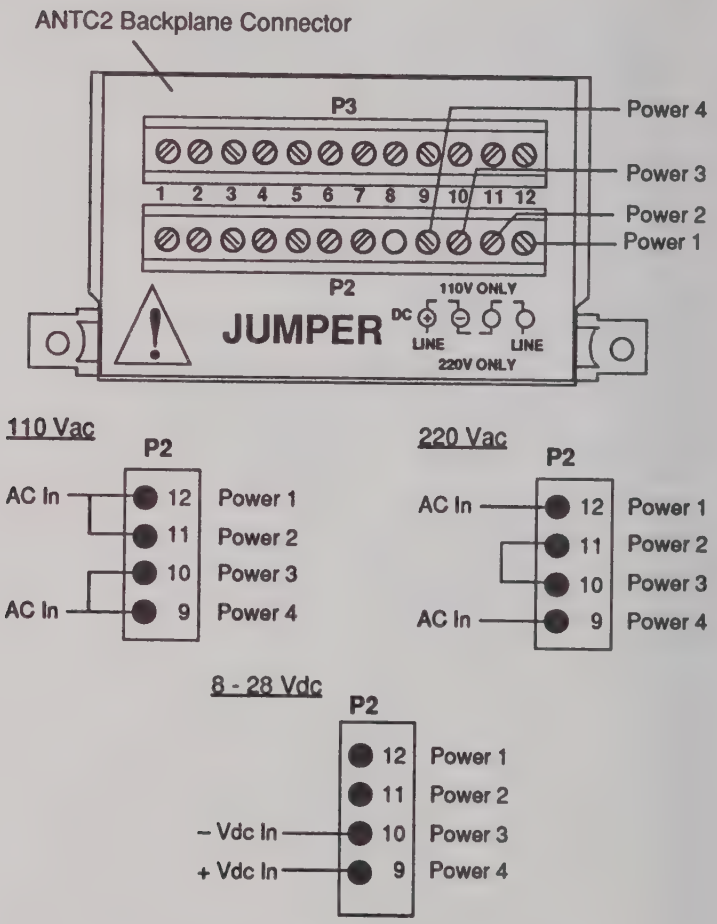



**Figure 2-11. Power Connections Using the ANTC2**

# 3 INSTALLING OPTIONS

## 3.1 INTRODUCTION

Champion Series options are added to a panel meter by installing an optional circuit board inside the case. Two types of option boards are used, the small option board shown in Figure 3-1 and the large option board shown in Figure 3-2. The component content and layout of these boards will differ based upon the ordered options. Note that the Analog Output and Excitation options have jumper-selectable output levels. No jumper selections are necessary for the RS232 option.

## 3.2 HARDWARE COMPATIBILITY

Meters with ac-powered main circuit boards – revisions 5D and 5E, and 6A and higher – will operate only with the option boards listed in Tables 3-1 and 3-2 at the specified revision levels or higher. The same applies for meters with dc-powered main circuit boards, revision 3 and higher. All these option boards use 12-pin connectors for P1 and P2. All option boards having an 8-pin connector for P2 are incompatible with the main circuit boards described above. The meter's revision number is located on the component side of the main circuit board.

**Table 3-1. Small Option Board Data**

| Applicable Models | Option Board |
|---|---|
| AN24A – Dual Relays & RS232<br>AN24D – RS232<br>AN24E – Dual Relays | 11212 (Rev. 6 & up) |
| AN24X1 – Excitation<br>AN24XE – Dual Relays & Excitation | 11214 (Rev. 1 & up) |

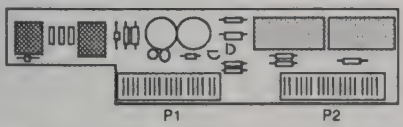



**Figure 3-1. Typical Small Option Board**

**Table 3-2. Large Option Board Data**

| Applicable Models | Option Board |
|---|---|
| AN24B – RS232, Dual Relays & Analog Out<br>AN24C – RS232 & Analog Out<br>AN24G – Analog Out<br>AN24H – Dual Relays & Analog Out | 11254 (Rev. 2 & up) |
| AN24XA – RS232, Dual Relays & Excitation<br>AN24XD – RS232 & Excitation | 14111 (Rev. 0 & up) |
| AN24XG – Analog Out & Excitation<br>AN24XH – Dual Relays, Analog out & Excitation | 11269 (Rev. 1 & up) |

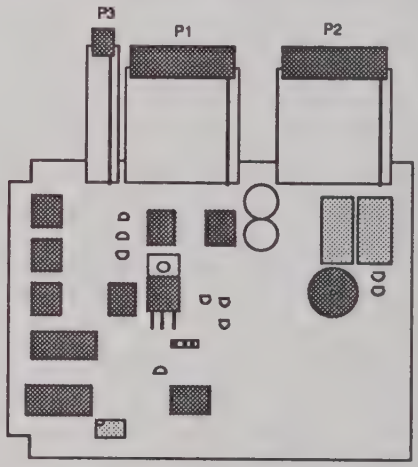



**Figure 3-2. Typical Large Option Board**

**CAUTION**

All Champion Series panel meters contain circuit devices which can be damaged by electrostatic discharge (ESD). To avoid damaging ESD-sensitive devices, we recommend that you use the following techniques when installing or removing option boards.

(1) Wear a grounded wrist strap before removing the electronic assembly from the plastic case.

(2) Temporarily store the electronic assembly in an anti-static bag or container while mounting the case.

(3) If you need to change any jumper selections on the board, always work on a grounded work surface and wear a grounded wrist strap.

(4) Always use grounded tools on the instrument. Hand tools are grounded when held by someone wearing a grounded wrist strap, unless the tool has insulated handles.

## 3.3 INSTALLATION PROCEDURE

(1) Make any applicable jumper selections (see Table 3-3).

(2) Remove power from the instrument.

(3) Grasp the keypad door and pull the meter out of the case.

(4) If you are installing a *small* option board, align the small option board connectors P1 and P2 with the pins of J1 and J2 on the main board (see Figure 3-5). Gently push the small option board down onto J1 and J2.

**CAUTION**

Any misalignment between the small option board connectors and the pins of J1 and J2 may cause damage to either or both circuit boards.

If you are installing a *large* option board, align the large option board connectors P1, P2 and P3 (if used) with the pins of J1, J2 and J4 on the main board (see Figure 3-6). Gently push the large option board connectors down onto J1, J2 and J4.

**CAUTION**

The blue stripe on the flat cables indicate the location of pin 1. Pin 1 of the cable connection should be aligned with pin 1 of the main board pin jacks J1 , J2 and J4. Any misalignment between the large option board connectors and the pins of J1, J2 or J4 may cause damage to either or both circuit boards.

(5) Return the instrument to its case.

(6) See your User's Manual for signal connections and operation.

**Table 3-3. AN2400 Options Installation Index**

| Model | Included Options | Jumper Selections |
|---|---|---|
| AN24A | RS232 & Relays | None. |
| AN24B | RS232, Relays & Analog Out | Analog Out, J1; See Fig. 3-4. |
| AN24C | RS232 & Analog Out | |
| AN24D | RS232 | None. |
| AN24E | Relays | None. |
| AN24G | Analog Out | Analog Out, J1; See Fig. 3-4. |
| AN24H | Relays & Analog Out | |
| AN24X1 | Excitation | Excitation, J1 & J2; See Fig. 3-3. |
| AN24XA | RS232, Relays & Excitation | Excitation, J2 and J3; |
| AN24XD | RS232 & Excitation | See Fig. 3-4. |
| AN24XE | Relays & Excitation | Excitation, J1 & J2; See Fig. 3-3. |
| AN24XG | Analog Out & Excitation | Analog Out, J1; Excitation, |
| AN24XH | Relays, Analog Out & Excitation | J2 and J3; See Fig. 3-4. |

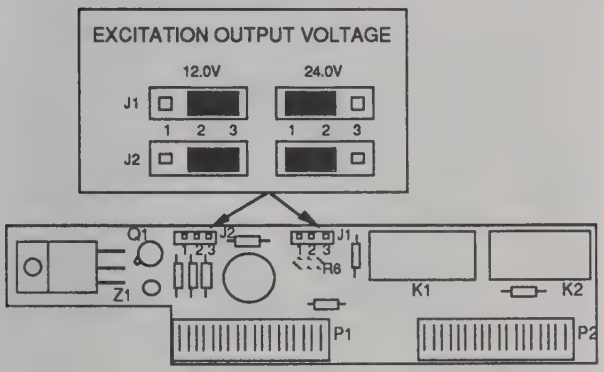



**Figure 3-3. Small Option Board Jumper Locations**

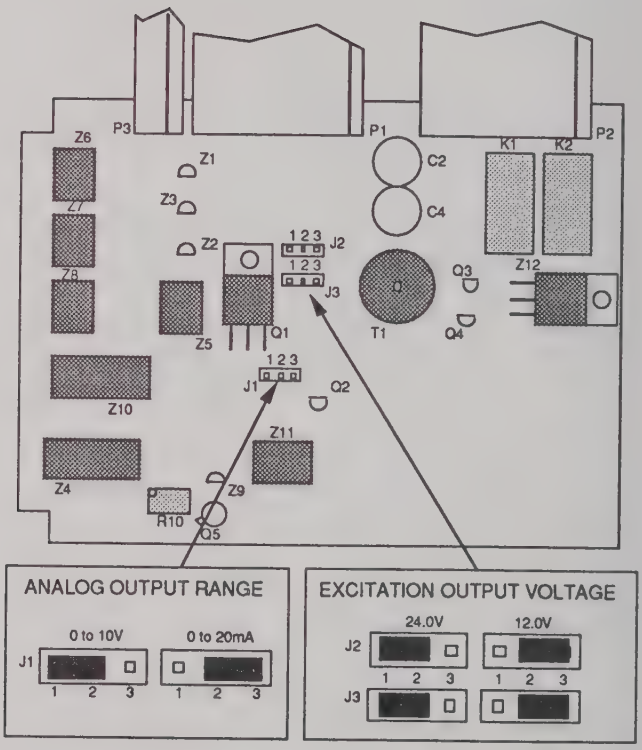



**Figure 3-4. Large Option Board Jumper Locations**

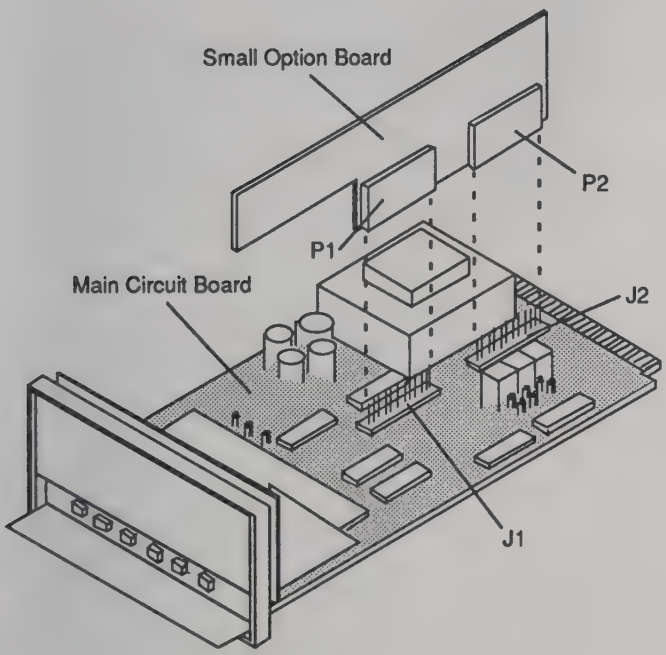



**Figure 3-5. Small Option Board Installation**

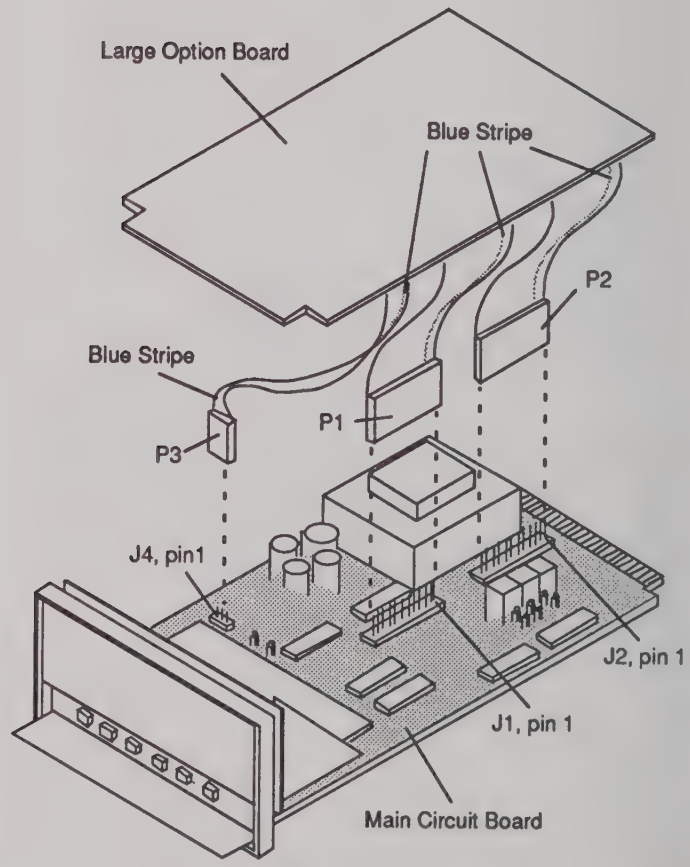



**Figure 3-6. Large Option Board Installation**

# 4 OPERATING INSTRUCTIONS

## 4.1 INTRODUCTION

This section consists of operating information and procedures for the AN2406. It describes the front panel display and controls, error indications and menu functions. It also includes instructions for using the available options. Before operating the AN2406, make sure that it has been installed properly.

## 4.2 FRONT PANEL DISPLAY AND CONTROLS

The front panel consists of a five-character display and a six-key keypad.

### 4.2.1 The Display

The elements of the display are described in Figure 4-1. The display consists of five multi-segmented characters with decimal points between each character. It can display any number between –19999 and 99999. The display also includes two vertical red signal bars on either side of the five characters used as status indicators. Both left-hand signal bars are lit when you scroll through either of the two function menus. The right-hand signal bars go on and off to indicate the tripped/untripped status of relays 1 and 2 (optional hardware).

### 4.2.2 The Keypad

The keypad is the basic user interface with the meter's microprocessor. Table 4-1 describes the individual key functions.

## 4.3 NORMAL OPERATION

When displaying a user-calibrated and scaled input signal, the meter is operating in the *Normal Display Mode.* The value displayed in this mode can also be called the *Scaled Display.* While in the Normal Display Mode, the Menu Scrolling indicators are off and the Setpoint indicators go on and off according to user-specified levels.

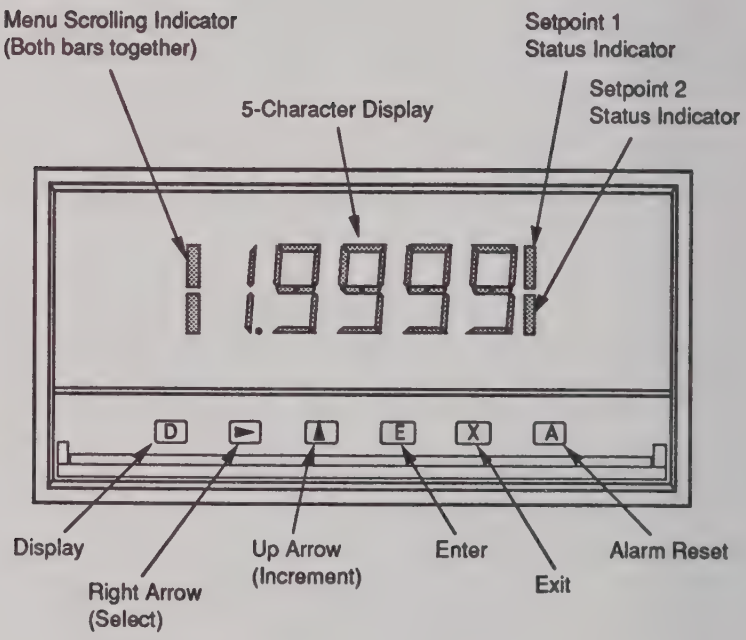
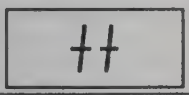



**Figure 4-1. Front Panel Layout**

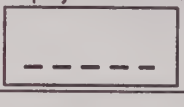
**Table 4-1. Keypad Functions**

| Key | Function |
|---|---|
| [D] | Steps through the Display and Set-up Parameter menus. Also sets the decimal point during numeric entry. |
| [►] | Selects the next digit to the right during numeric entry mode. Selected digit flashes. The selected display value can be entered after selecting right-most digit by pressing the "E" key. |
| [▲] | Increments the selected digit during numeri entry mode. After reaching 9 the digit returns to 0 without affecting any other digits. The left-most digit's sequence is "–, –1, 0, 1, 2,....., 8, 9. |
| [E] | Enters the displayed value into parameter memory. Resets Peak value and Valley value to current reading. Loads default set-up and calibration values if depressed during power-up. |
| [X] | Cancels the present operation and returns to the normal display mode. When depressed, this symbol appears on the display:  |
| [A] | Enables resetting of manual alarms. When depressed, this symbol appears on the display: |

## 4.4 ERROR DISPLAYS

Special symbols appear on the five-character display to indicate one of three error conditions (see Table 4-2). Note that while any type of error symbol is displayed, the Setpoints can trip unless they are set to inactive states using parameters P1 and P2 in the Set-Up Menu.

**Table 4-2 Error Conditions**

| Error Display | Description |
|---|---|
| Bad or no A/D Conversion | The input signal exceeds the nominal FS range by more than 10% (i.e., if the input is ≥ ± 2.2Vdc on the ± 2-volt range or if the input signal is constantly changing by more than 20% of the range during a conversion). |
| Display Over-Range | Input signal exceeds the nominal plus FS range less one digit of resolution (i.e., if the input is more than +1.9999 on the ± 2-volt range or if a display greater than 99999 is attempted. |
| Display Under-Range  | Input signal exceeds the nominal minus FS range less one digit of resolution (i.e., if the input is less than –1.9999 on the ± 2-volt range or if a display less than –19999 is attempted. |

## 4.5 FUNCTION MENUS

The AN2406 functions are organized into a Display Menu and a Set-Up Menu and are accessed from the normal display mode using the keypad. The flow diagram in Figure 4-2 shows you the functions in both menus in the order that they appear as you scroll through them. To exit either menu at any time, press the X key and the meter will return to the normal display mode.

### 4.5.1 Scrolling Through the Display Menu

While scrolling through the Display Menu, note the unique operation of the D key. If you press and hold D, the display shows the mnemonic of the next selected function. When you release the D key the display shows the value of the selected function. While the value is displayed, it can be changed using the right and up arrow keys.

To scroll through the Display Menu, press and hold D to enter the Display Menu and select the first function, I. Release D to display the value of that function. Continue to press and release D to select other functions. After the last function, press D once more to return to the normal display mode.

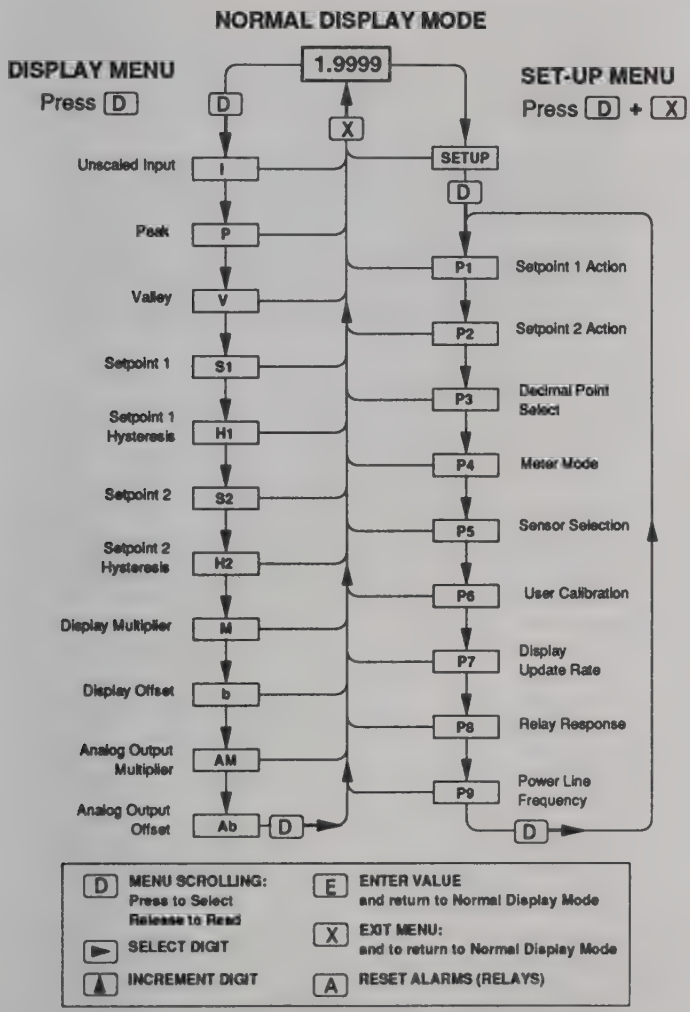



Figure 4-2. AN2406 Menu Functions Flow Diagram

### 4.5.2 Scrolling Through the Set-Up Menu

While scrolling through the Set-Up Menu, the Menu Scrolling Indicators are on and the Setpoint indicators operate as if the meter is still in the normal display mode.

To scroll through the Set-Up Menu, press and release the D and X simultaneously to enter the Set-Up Menu. Note that the display shows the word "SETUP". Press and hold D to select the first function (P1). Release D to display the parameter value. Continue to press and release the D key to scroll through the rest of the menu. After displaying the last function value, press D once more to return to the first parameter.

## 4.6 USING THE DISPLAY FUNCTIONS

The Display Menu functions are described in Table 4-3. All display functions, except the Unscaled Input Display (I), Peak (P) and Valley (V), operate according to user-specified function values. While the value is displayed it can be changed using the right and up arrow keys. The Setpoint and Hysteresis functions apply only to the Dual Relay Option (see Section 4.8). The Analog Output functions apply only to the Analog Output Option (see Section 4.9).

**NOTE**

Table 4-3 lists default values. To enter default values, press and hold the Enter key (E) during power-up.

### 4.6.1 Entering/Changing Display Function Values

To enter or change a function value:

(1) Using the D key, enter the menu and scroll to the desired function.

(2) Press the right arrow key. The left-most digit should blink indicating that it has been selected. Keep pressing the right arrow key until the desired digit is selected.

(3) Press the up arrow key to increment the digit to the appropriate value or press the right arrow key to select the next digit.

(4) After adjusting the value of all digits, press right arrow until the right-most digit is selected.

(5) Press and release the E key to enter the total value and return the meter to the normal display mode.

**Table 4-3. Display Menu Functions**

| Function | Value (# Cnts) | Description |
|---|---|---|
| I Unscaled Input Display | –19999 to 99999 (Default = 0) in units of 0.1 °F | Unscaled input value before M and B are applied. A displayed value only, cannot be altered via the keypad. |
| P Peak | | Most positive value read during the normal display mode since the last reset. Press the E key to reset and return to the normal display mode. |
| V Valley | | Most negative value read during the normal display mode since the last reset. Press the E key to reset and return to the normal display mode. |
| S1 Setpoint 1 | –19999 to 99999 (Default = 0) | Display value which causes Relay 1 to trip and the status indicator to light. |
| H1 Setpoint 1 Hysteresis | 0 to 409 (Default = 0) | Deadband amount which causes Relay 1 to untrip. |
| S2 Setpoint 2 | –19999 to 99999 (Default = 0) | Display value which causes Relay 2 to trip and the status indicator to light. |
| H2 Setpoint 2 Hysteresis | 0 to 409 (Default = 0) | Deadband amount which causes Relay 2 to untrip. |
| M Display Multiplier | .0001 to 9999 (Default = 1) | A multiplier used to scale the unscaled input value (I) primarily for converting measurements. Use D key to set decimal point (see Section 4.6.3). |
| b Display Offset | –19999 to 99999 (Default = 0) | An offset used to scale the unscaled input value (I) primarily for converting measurements. |
| AM Analog Output Multiplier | .0001 to 9999 (Default = 1) | A multiplier used to scale the optional analog output signal. Use the D key to set decimal point (see Section 4.6.3). |
| Ab Analog Output Offset | –19999 to 99999 (Default = 0) | An offset used to scale the optional analog output signal. |

### 4.6.2 Display Scaling

The Scaled Display is produced using the expression, MI + b, where M = Display Multiplier, I = Unscaled Input, and b = Display Offset. M and b are automatically set for the desired temperature unit when the temperature range is selected by parameter P4 in the Set-Up Menu (see Section 4.7). When using one of the standard ranges, M and b should not be altered. However, to use a non standard display unit such as Kelvin or Rankin, M and b may be changed using the numeric entry procedure.

Although the meter performs scaling separately for the display and the analog output, the process is the same for both. For example, a 212°F sensor temperature produces an unscaled temperature value of 2120 based on the default display units of 0.1°F. A centigrade scaled display (100°C) is calculated by the meter using the expression above.

$$\text{Scaled Display} = (M \bullet \text{Unscaled Input}) + B = MI + b$$

The correct M and b values are automatically established when you select the desired display units using Set-Up parameter P4. Values for M and b are determined by the relationship between Fahrenheit and Celsius temperature scales.

$$°C = \frac{5}{9} \bullet (°F - 32) = \left(\frac{5}{9} \bullet °F\right) - 17.777$$

Therefore, the scaling factors for a °F-to-°C conversion are:

$$M = \frac{5}{9} = 0.55555 \qquad B = -17.777$$

But, because the Unscaled input is in *tenths* of a °F, the M multiplier is one tenth of the above value. Scaling the display for units of 1°C thus requires M and B values of:

$$M = 0.055555 \qquad B = -17.777$$

Figures 4-3 and 4-4 illustrate how the meter performs display scaling. These show how the meter translates Unscaled input counts (in the default °F units) into display counts using appropriate factors for multiplier (M) and offset (B).

*Example:*

In a temperature monitoring application, where the nominal operating temperature is 90°F, it is possible to have deviations of up to 20°F on either side of the nominal. Rather than display actual temperature, you want the display to indicate deviation from nominal as a percentage of the permissible value. In other words, at a temperature of 90° the display should read zero. At 110° it should read 100. At 70° it should read –100.

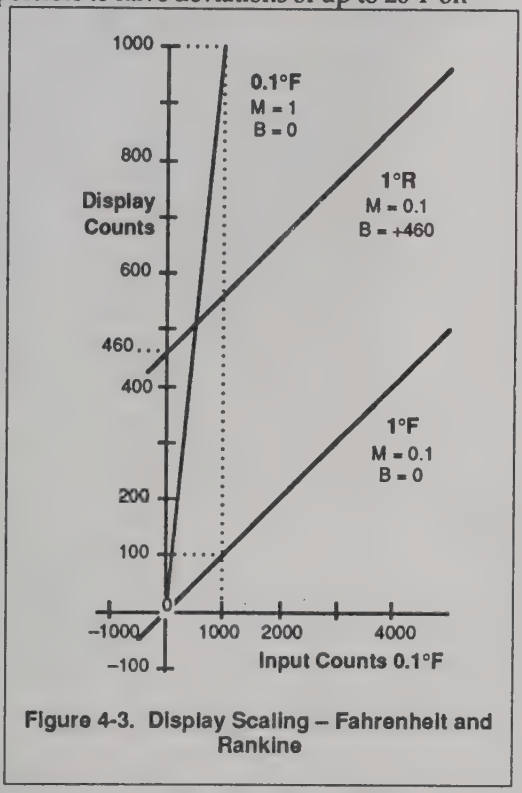



Figure 4-3. Display Scaling – Fahrenheit and Rankine

Since the base input unit is 0.1°F, a change of 200 input units (20.0°F) should result in 100 display units. Therefore,

$$M = 100/200 = 0.5$$

A display value of 0 should be 90°F, so 'b' may be calculated as

$$b = 0 - (0.5 \times 900) = -450$$

If you wanted a 5° deviation from 90° to give the same results, then

$$M = 100/50 = 2$$
$$b = 0 - (2.0 \times 900) = -1800$$

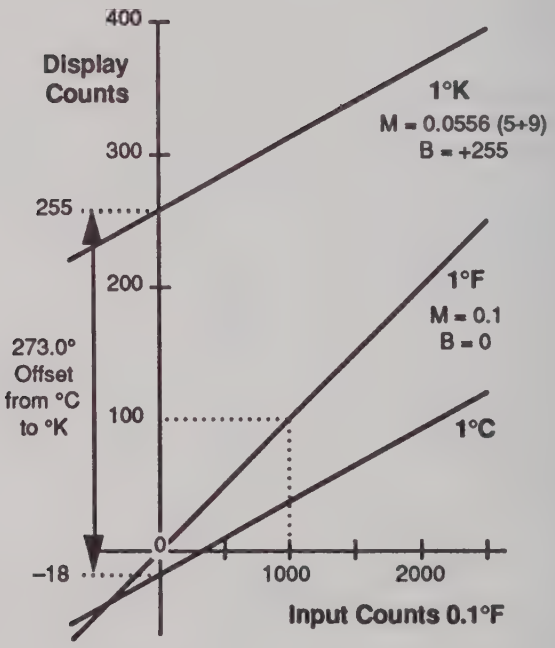



**Figure 4-4. Display Scaling – Celsius and Kelvin vs Fahrenheit**

### 4.6.3 Decimal Point Positioning

When changing the the Display Multiplier (M) and the Analog Output Multiplier (AM), the decimal point position can be changed. To move the decimal point, first press the right arrow key. Then press D to reposition decimal point. Press the right arrow key again to continue numeric entry.

## 4.7 USING THE SET-UP FUNCTIONS

The Set-Up Menu functions are described in Table 4-5. These functions are defined by user-entered parameter values. While a parameter value is displayed it can be changed using the right and up arrow keys. The Enter (E) key stores the parameter value in memory and returns the meter to the normal display mode. The Setpoint and Hysteresis functions apply only to the Dual Relay Option (see Section 4.8).

**NOTE**

Table 4-5 lists default values. To enter default values, press and hold the Enter key (E) during power-up.

### 4.7.1 Entering/Changing Parameter Values

To enter or change a parameter value:

(1) Enter the Set-Up Menu by pressing X and D simultaneously and use the D key to scroll to the desired function.

(2) Press the right arrow key. The left-most digit should blink indicating that it has been selected. Keep pressing the right arrow key until the desired digit is selected.

(3) Press the up arrow key to increment the digit to the appropriate value or press the right arrow key to select the next digit.

(4) After adjusting the value of all digits, press right arrow until the right-most digit is selected.

(5) Press and release the E key to enter the total value and return the meter to the normal display mode.

**Table 4-5 Set-Up Menu Functions**

| Parameter | Description | Parameter Values |
|---|---|---|
| P1 Setpoint 1 Action | Relay 1 trip action. | 0 = Setpoint Off (Default)<br>1 = Trip on rising input, Manual Reset<br>3 = Trip on falling input, Manual Reset<br>5 = Trip on rising input, Auto Reset<br>7 = Trip on falling input, Auto Reset |
| P2 Setpoint 2 Action | Relay 2 trip action. | Same as above. |
| P3 Decimal Point Select | Displayed decimal point position. | 0 = 99999 (Default)<br>1 = 9999.9<br>2 = 999.99<br>3 = 99.999<br>4 = 9.9999 |
| P4 Meter Mode | Temperature range. | 0 = Not Used (Default)<br>1 = ± 200 mV<br>2 = Not Used<br>3 = Not Used<br>4 = 0.01 °C/count<br>5 = 0.1 °C/count<br>6 = 1 °C/count<br>7 = 0.1 °F/count<br>8 = 1 °F/count<br>9 = 0.1 °K/count (Option) |
| P5 Sensor Selection | Thermistor, RTD or Cryogenic Selection | 0 = Thermistor: 252 Ω @ 0°C, 2-wire (Default)<br>1 = RTD: 100 Ω, Alpha = 0.003850, 2-/4-wire<br>2 = RTD: 100 Ω, Alpha = 0.003850, 3-wire<br>3 = RTD: 100 Ω, Alpha = 0.003916, 2-/4-wire<br>4 = RTD: 100 Ω, Alpha = 0.003916, 3-wire<br>5 = Cryogenic RTD: 100 Ω, Alpha = 0.003850, 2-/4-wire (Option)<br>6 = Cryogenic RTD: 100 Ω, Alpha = 0.003850, 3-wire (Option) |
| P6 Calibration | User calibration. | 0 to 99999 (See Section 4.7.3) |
| P7 Display Update Rate | Rate of display update. | 0 = 14 – 18Hz (Default)<br>1 = 3Hz<br>3 = 1Hz<br>7 = 0.5Hz |
| P8 Relay Response | Relay operational characteristics. (See Section 4.8) | 0 = Normal Operation<br>1 = Special Operation<br>2 = Fail-Safe Operation (Default) |
| P9 Power Line Frequency | 50/50 Hz line input adjustment. | 0 = 50Hz line frequency<br>1 = 60Hz line frequency (Default) |

### 4.7.2 Decimal Point Positioning

Parameter P3 changes the position where the decimal point appears. Note that the meter always displays an integer value. The decimal point is strictly a user convenience

### 4.7.3 Selecting Temperature Range (Display Units)

When Fahrenheit or Celsius display units are selected by parameter P4, the meter automatically stores the correct scaling factors in the M and b registers, and returns to normal operation. These are the automatically-entered scaling factors:

For 1°F resolution M = 000.1, b = 0000
For 0.1°F resolution M = 0001, b = 000.0
For 1°C resolution M = 0.0556, b = –0017
For 0.1°C resolution M = 0.5556, b = –017.7
For 0.01°C resolution M = 5.556, b = –17.77

**NOTE**

For correct °F or °C temperature displays, do not change the automatically set M and b values. The display decimal point is automatically positioned.

Although M and b are automatically set by range selection, other temperature ranges such as Rankine and Kelvin may be selected by changing M and b. Refer to the Table 4-6 for the respective M and b values to enter for °K or °R.

**Table 4-6. M & B Values vs Temperature Range**

| Range | M | b | Use P4 = |
|---|---|---|---|
| 1 °K | 0.0556 | 255 | 6 for 1 °C |
| 0.1 °K | 0.0556 | 255.4 | 5 for 0.1 °C |
| 1 °R | 000.1 | 460 | 8 for 1 °F |
| 0.1 °R | 0001 | 459.7 | 7 for 0.1 °F |

Set the decimal point position where desired using parameter P3. An easier way to select Rankin or Kelvin is to first select the corresponding Fahrenheit or Celcius Display Units with P4 as listed above, and then change only the b value, not the M value or decimal point position.

### 4.7.4 User Calibration for RTDs

The AN2406 is factory calibrated to meet the standards of IEC 751 for Platinum RTDs with $R_0$=100Ω and Alphas of 0.00385 and 0.00392. Since commercially available RTDs can deviate from the standard by up to 0.5°C, you may want to "user-calibrate" the AN2406 to match a given detector. To user-calibrate for a detector, do the following:

(1) Connect the RTD (or a resistance standard if the resistance level for the calibration temperature is known). The four-wire connection is recommended for the greatest accuracy (see Section 2.9).

(2) Place the RTD in a constant temperature bath which has been brought to the calibration temperature. (Or set the resistance standard to the equivalent resistance.)

(3) While in the normal display mode, press the D and X keys simultaneously to enter the SETUP mode.

(4) Press and hold the D key repeatedly until P6 appears in the display. Releasing the D key displays the current temperature in tenths of a °F.

(5) Using the right and up arrow keys, adjust the displayed number to match the desired temperature indication. Do not enter zero or a negative value.

(6) Press the E key.to store the new value and return to the normal display mode.

### 4.7.5 User Calibration for Thermistors

The AN2406 is factory calibrated for Platinum RTDs. For Thermistor readout, recalibrate as follows:

(1) Set a resistance standard to 1200 ± 0.5Ω and connect it to the AN2406. The two-wire connection is recommended for the greatest accuracy (see Section 2.9).

(2) While in the normal display mode, press the D and X keys simultaneously to enter the SETUP mode.

(3) Scroll to parameter P5. Using the right and up arrow keys, set P5 = 0 (Thermistor type device). Press the E key.to store the new value and return to the normal display mode.

(4) Scroll to parameter P4. Set P4 = 1 ( 200 mV range). Press the E key.to store the new value and return to the normal display mode.

(5) Scroll to parameter P6. Set P6 = 115.12. Press the E key.to store the new value and return to the normal display mode.

(6) Set P4 to 7 (0.1°F readout) and verify a reading of 104.0°F; or set P4 to 4 (0.01°C readout) and verify a reading of 40.00°C.

## 4.8 USING THE RELAY OUTPUT OPTION

The Relay Ouput Option equips a panel meter with dual-relay outputs. If this option was not installed at the factory, refer to Section 3 for installation information.

Relay operation is characterized by two Reset Modes (P1 and P2) and three Relay Response Modes (P8). The characteristics of each mode of operation are described below. The tripped/untripped relay states are defined for each operating mode in Figure 4-5.

### 4.8.1 Reset and Action Modes

Relay operation is determined by the Reset and Action modes selected by parameters P1 and P2 in the Set-Up Menu. Reset modes include manual and automatic. Trip action can be rising or falling.

In the *Manual Reset Mode.*, once a relay is tripped, it remains tripped until you press the Alarm (A) key and the scaled displayed value changes to a value that untrips the relay.

In the *Automatic Reset Mode.*, a tripped relay remains tripped until the scaled displayed value changes to a value that untrips the relay - no user interaction involved.

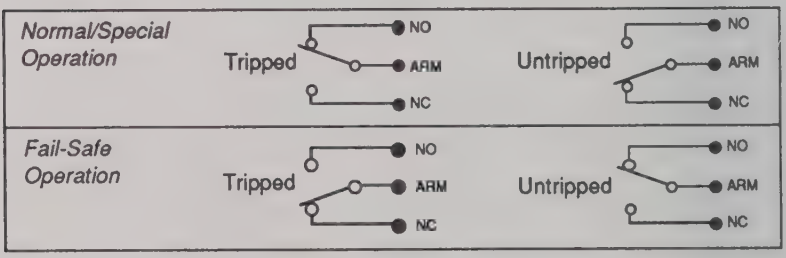



**Figure 4-5. Relay States**

A relay may trip on a rising or a falling input signal as specified by the Setpoint parameters P1 and P2. Figure 4-6 illustrates typical relay operation. On a rising signal, a relay trips when the display is equal to or greater than the Setpoint. The relay will be untripped if the display drops to a value that is less than the Setpoint minus the Hysteresis or Deadband value (H1 and H2). On a falling signal, a relay trips when the display is equal to or less than the setpoint value. The relay will be untripped if the display rises to a value that is more than the Setpoint value plus the Hysteresis.

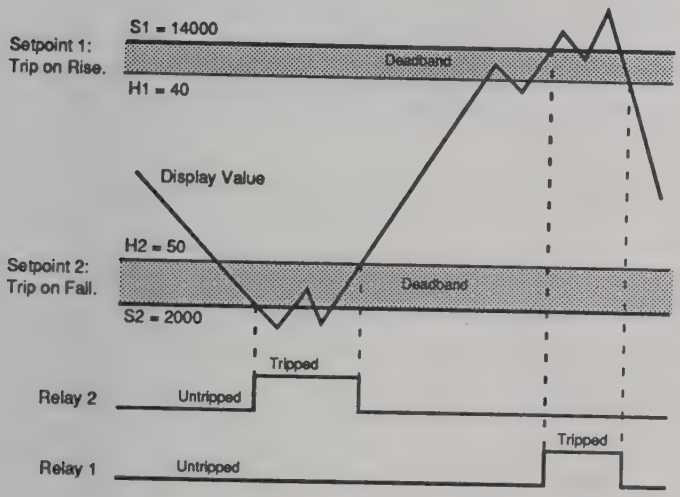



**Figure 4-6. Typical Relay Setpoint Operation**

### 4.8.2 Relay Response Modes

The Relay Response Modes listed below are controlled by the value of parameter P8. The characteristics of each operating mode are described below. In each mode, the relays trip or untrip on one or any combination of the listed conditions.

**NOTE**

Relays will trip when P1 and P2 are not set to 0 and the display reads overbars, underbars or double bars.

*Normal Operation (P8 = 0).*

Relay 1 or 2 *trips* when...

- The display value reaches or exceeds the Setpoint.
- The display value exceeds the high/low range of the meter.
- The meter cannot perform an A/D conversion.

Relay 1 or 2 is *untripped* when the display value returns to the Setpoint, including the Hysteresis value (see figure above), or the power is off.

*Special Operation (P8 = 1).*

Relay 1 or 2 *trips* when the display value reaches or exceeds the Setpoint.

Relay 1 *trips* when...

- The display value exceeds the high/low range of the meter.
- The meter cannot perform an A/D conversion.

Relay 1 or 2 is *untripped* when the display value returns to the Setpoint, including the Hysteresis value (see figure above), or the power is off.

Relay 2 is *untripped* if...

- The display value exceeds the high/low range of the meter .
- The meter cannot perform an A/D conversion.

*Fail-Safe Operation (P8 = 2).*

Relay 1 or 2 *trips* when...

- The display value reaches or exceeds the Setpoint.
- The displayed value exceeds the high/low range of the meter.
- The meter cannot perform an A/D conversion.
- The power is off.

Relay 1 or 2 is *untripped* when the display value returns to the Setpoint, including the Hysteresis value (see figure above).

## 4.9 USING THE ANALOG OUTPUT OPTION

The Analog Output Option provides a current output of 0 to 20 milliamperes or a voltage output of 0 to 10 volts dc and is jumper-selectable. This output is fully isolated from all other portions of the AN2406 and from ground. If this option was not installed at the factory, refer to Section 3 for installation instructions.

**NOTE**

When the display reads overbars, underbars or double bars, the analog output will be 0 V in the voltage mode or 0 mA in the current mode.

### 4.9.1 Analog Output Scaling

The analog output can be scaled independently of display scaling using the display menu functions AM and Ab (see Table 4-3). The scaled output is calculated by the microprocessor using the following expression:

Analog Output = AMX + Ab

where: AM = Analog output multiplier from .0001 to 9999
I = Unscaled Display Value (0.1 °F/count)
Ab = Analog Output Offset from –19999 to 99999

The product of I and AM is transmitted to the analog output module which turns the digital information into an equivalent voltage or current. To calculate the required AM and AB values for your application, refer to the scaling graph Figure 4-7 and the formulas and examples that follow.

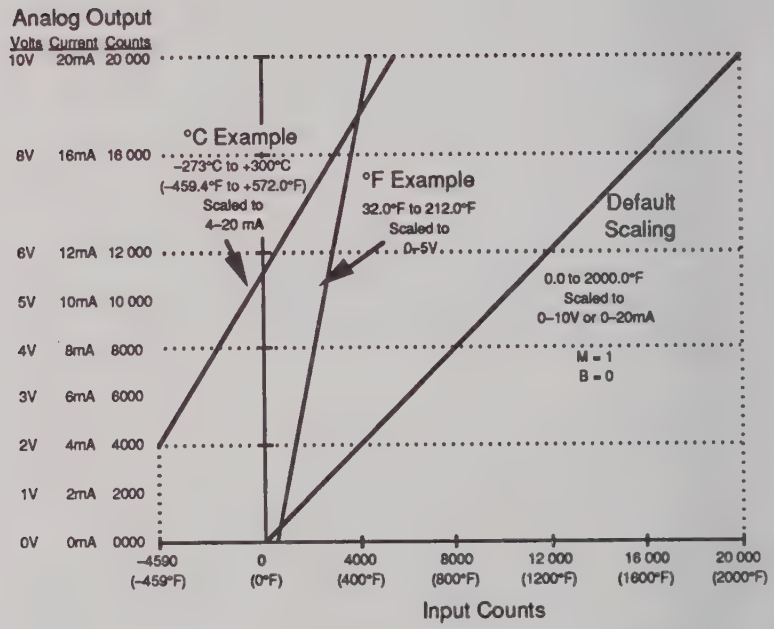



**Figure 4-7. Typical Analog Output Scaling Graph**

### 4.9.2 Simplified Scaling Using Dummy Display Counts

To simplify calculations, think of the analog output in terms of a dummy display whose range is zero to 20000. If the scale factor and offset are calculated in terms of this dummy display, the analog output will be correct independently of whether voltage or current output is selected. To calculate the AM (slope) and Ab (offset) parameters to be entered:

(1) Decide the desired temperature range (low and high values) and corresponding Analog Output range (low and high values).

(2) Convert the °F values into 0.1°F Unscaled display counts (× 10).

(3) Convert desired analog output values into dummy display counts (mA × 1000, V × 2000), as illustrated in Figure 4-7.

(4) Calculate AM and Ab as follows.

$$AM = \frac{\text{Range of Analog Output}}{\text{Range of Unscaled Display}} = \frac{AnOut_{High} - AnOut_{Low}}{UD_{High} - UD_{Low}}$$

$$Ab = AnOut_{Low} - (AM \times \text{Unscaled display}_{Low})$$

Where Unscaled display and Analog Output are in counts (+ or –).

AM limits are 0.0001 to 99.99, in 0.0001 steps, default is 1.
Ab Limits are –19999 to +79999, in steps of 1, default is 00000.

**Example 1:**

You want to transmit a 0–500°F temperature range as a 0–20 mA output. Note that 500°F is 5000 counts in the Unscaled display (0.1°F resolution).

$$AM = \frac{\text{Range of Analog out}}{\text{Range of Unscaled display}} = \frac{20000 - 0}{5000 - 0} = 4$$

$$Ab = AnOut_{Low} - (AM \times \text{Unscaled display}_{Low}) = 0 - (4 \times 0) = 0$$

**Example 2:**

You want to transmit a 0–500°F temperature range as a 4–20 mA output.

$$AM = \frac{\text{Range of Analog out}}{\text{Range of Unscaled display}} = \frac{20000 - 4000}{5000 - 0} = \frac{16000}{5000} = 3.2$$

$Ab = AnOut_{Low} - (AM \times Unscaled\ display_{Low})$
$Ab = 4000 - (3.2 \times 0) = 4000$

**Example 3**

You want to transmit a 50–100°F temperature range as a 1-5 V output. Converting the desired output voltage limits input dummy display counts using the 2000 multiplier as specified in step 3 above:

$$AM = \frac{\text{Range of Analog out}}{\text{Range of Unscaled display}} = \frac{10000 - 2000}{1000 - 500} = \frac{8000}{500} = 16$$

$Ab = AnOut_{Low} - (AM \times Unscaled\ display_{Low})$
$Ab = 2000 - (16 \times 500) = -6000$

**Example 4:**

You want to transmit a 0–50°C temperature range as a 4–20 mA output. First convert the centigrade readings to Fahrenheit

$0°C = 1.8 \times 0 + 32 = 32.0°F$
$50°C = 1.8 \times 50 + 32 = 122.0°F$

$$AM = \frac{\text{Range of Analog out}}{\text{Range of Unscaled display}} = \frac{20000 - 4000}{1220 - 320} = \frac{16000}{900} = 17.78$$

$Ab = AnOut_{Low} - (AM \times Unscaled\ display_{Low})$
$Ab = 4000 - (17.78 \times 320) = -1690$

### 4.9.3 Limits on Analog Output Scaling

The above examples show that the full range of analog output may be obtained over a relatively small range of input. This is because of the high internal resolution of the instrument and the fact that analog output is obtained before display scaling.

The internal resolution of the linearization table is 0.01°F. Due to round-off in the mathematics, a practical number is 0.02°F. To obtain full resolution of the 12-bit D/A converter for analog output, 4096 discrete values are needed within the input range. With the 0.02°F resolution of the input, this means that the difference between minimum and maximum temperature values should be at least 4096 × 0.02 = 81.92°F or 27.73°C. At this limit, up to ± 8 mV of noise can be expected on the output on the 10 volt range. For most analog output applications (Strip chart recorders, PLC interfaces, etc.), this amount of noise is insignificant. Often less than full D/A resolution is acceptable. For example, to achieve a resolution of 1 part in 1000 (0.1%), only a 20°F range is required.

### 4.9.4 Analog Output Calibration

The analog output is calibrated at the factory for the 20 mA range. A voltage output is obtained by passing 20 mA through a 0.1%, 500Ω resistor. If you wish to recalibrate, use the following procedure:

(1) Remove the meter from its case. Using an auxiliary connector, apply power and an input to the meter. The rear connector can be removed from the case and used for this purpose.

(2) Depending upon the selection of jumper J1, connect a current or voltmeter to the Analog Output pins (P1-L (+) and P1-12 (–). Set the current/voltmeter to the appropriate scale.

(3) Enter the Display Menu and set AM to 0 and Ab to 20000. Adjust R10 (see Figure 4-8) for the appropriate reading.

(5) Remove power from the meter, disconnect the auxiliary connector and return the meter to its case.

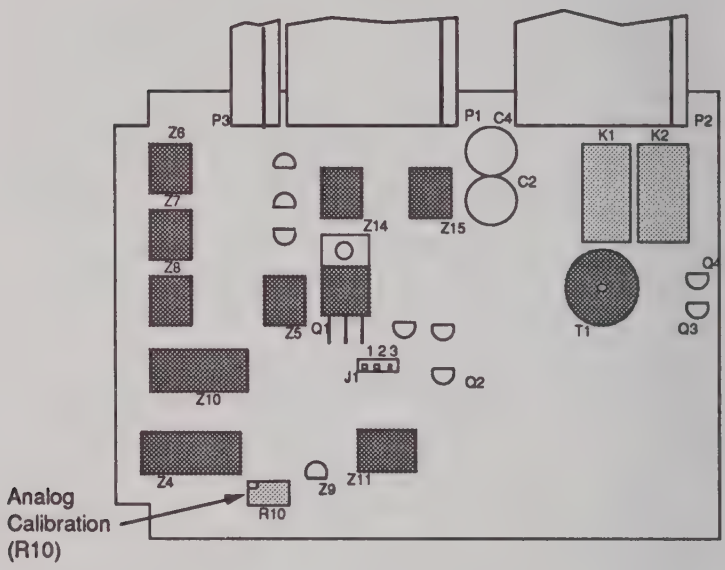



**Figure 4-8. Typical Analog Option Board**

## 4.10 USING THE EXCITATION OPTION

The Excitation Supply option provides 24 or 12 volts dc at 24 milliamps for powering external devices such as a current loop transmitter. The wiring diagram in Figure 4-9 shows the typical wiring connections to a two-wire, current loop transmitter. The loop excitation is supplied through pins E (+) and F (–) of edge connector P1.

If the Excitation Supply was installed at the factory, you may want change the voltage level. To do this, remove the meter from the case and determine whether you have a small or large option board. Then change the selection jumpers according to Figure 4-10. If you have ordered this option separately, see Section 3 for installation instructions.

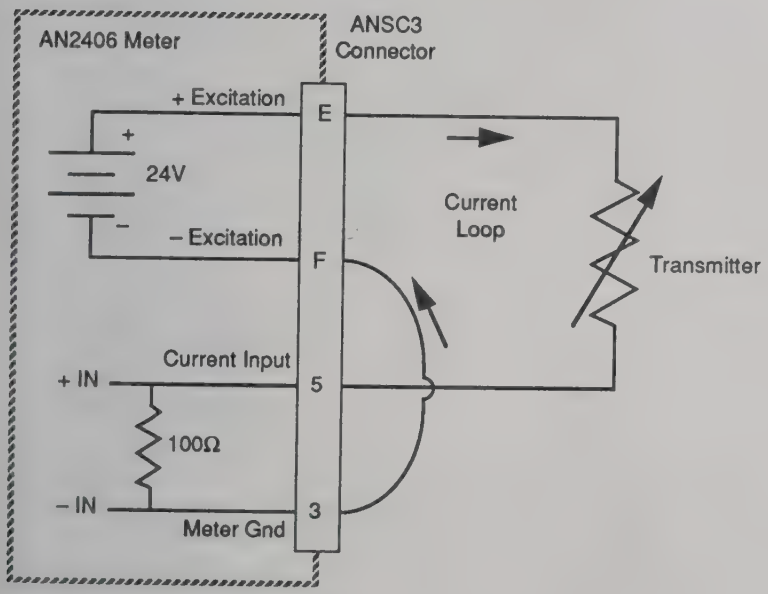



**Figure 4-9. Two-Wire Transmitter to AN2406 Wiring Diagram**

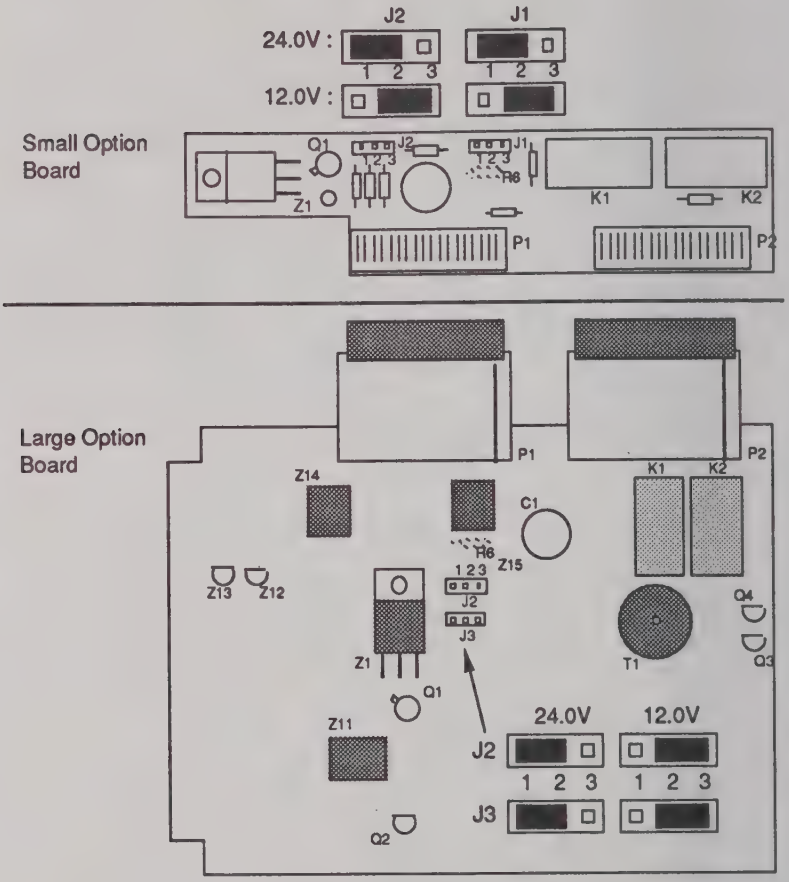



**Figure 4-10. Excitation Supply Selection Jumpers**

## 4.11 USING THE SERIAL COMMUNICATIONS OPTION

The Serial Communications Option is a standard RS232 interface that allows you to control the functions of the panel meter using a terminal or host computer. The AN2406 is programmed using three types of commands: Operate, Modify and Query commands. If any command is not understood by the meter, it responds by transmitting the characters "??"<CR>.

If this option was not installed at the factory, refer to the Section 3 for hardware installation and compatibility information.

### 4.11.1 Signal Connections

To connect the meter to a host computer or terminal, use a three-wire cable between P1 of the AN2406 and the 25-pin D type connector on the host. See Table 7-1.

**Table 4-7. RS232 Signal Connections**

| | AN2406 Connector | | Host/Terminal |
|---|---|---|---|
| Signal | ANSC3 | ANTC2* | (25-Pin D-Type) |
| Output | P1 – M | P3 – 10 | 2 |
| Input | P1 – N | P3 – 12 | 3 |
| GND | P1 – 13 | P3 – 11 | 7 |

* See Section 2.8 for hardware compatibility information.

### 4.11.2 Serial Data Format

The serial communications interface operates at 9600 baud with 1 start bit, 7 data bits, no parity and 2 stop bits. The LSB is transmitted first. Data is ASCII-coded BCD. Commands received by the panel meter are echoed back to the terminal or host. The transmitting device should verify that the echoed character matches the transmitted character for error control.

### 4.11.3 Operate Commands

Operate commands (Table 7-2) consist of two upper case letters followed by a carriage return, <CR>. When a valid Operate command is accepted by the meter, it outputs the characters "OK"<CR>.

### 4.11.4 Modify Commands

Modify commands (Table 7-3) consist of two upper case letters followed by a appropriate value and a <CR>. When a valid Modify command is accepted by the meter, it outputs the characters "OK"<CR>. The entered value may consist of up to seven characters. More than seven characters results in an error response of "??" followed by a <CR>.

### 4.11.5 Query Commands

Query commands (Table 7-4) consist of two upper case letters followed by a carriage return <CR>. When a valid Query command is accepted by the meter, it transmits an answer. The format of the answer is shown in Figure 7-1.

**NOTE**

The meter transmits "XXXXX" for underbars (out of range, low), "YYYYY" for overbars (out of range, high) and "=====" (five equal signs) for the double bar condition in response to Query commands XP, XV, XD and TD (menu parameters D, I, PK and VY only).

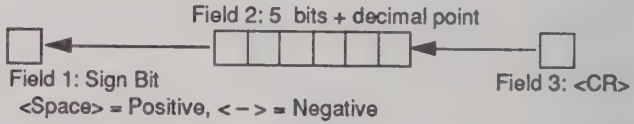



**Figure 4-11. Query Command Answer Format**

**Table 4-8. Operate Commands**

| Cmnd | Name | Function |
|---|---|---|
| RP | Reset Peak | Sets the value of the Peak register to the current display value. |
| RV | Reset Valley | Sets the value of the Valley register to the current display value. |
| AR | Alarm Reset | Resets any tripped setpoint in the manual mode which meets all conditions for staying reset. |
| SX | Transmit Scaled Display | Enables the meter to continuously transmit the scaled display with leading zeros, and a decimal point. |
| EX | End Continuous Xmit | Stops the continuous transmit mode enabled by command SX. |
| LO | Lock Out Keypad | Inhibits keypad operation. Keypad is unlocked when power is removed, unless the SV command is issued beforehand. |
| UL | Unlock Keypad | Allows normal keypad operation. Before using this command, jumper J6 must be installed. See Section 2.6. |

**Table 4-9. Modify Commands**

| Cmnd<arg> | Name | Function |
|---|---|---|
| DP<x> | Decimal Point Position | Sets the decimal point the requested number of spaces from the right, where <x> 0-4:<br>0 = 99999<br>1 = 9999.9<br>2 = 999.99<br>3 = 99.999<br>4 = 9.9999 |
| E1<xxxxx> | Enter Setpoint 1 | Sets Setpoint 1 register to entered value <xxxxx>, where x = 0-9. |
| E2<xxxxx> | Enter Setpoint 2 | Sets Setpoint 2 register to entered value <xxxxx>, where x = 0-9. |
| SV | Save | Saves all values upon power down except for Peak and Valley. |

**Table 4-10. Query Commands**

| Cmnd | Name | Transmitted Answer |
|---|---|---|
| XP | Xmit Peak* | Value stored in the Peak Register. |
| XV | Xmit Valley* | Value stored in the Valley Register. |
| XD | Xmit Display* | Display Value. |
| XR | Xmit Software Rev. | "REV.N". |
| O1 | Output Setpoint 1 | Value stored in Setpoint 1 Register. |
| O2 | Output Setpoint 2 | Value stored in Setpoint 2 Register. |
| TP | Transmit Set-Up Parameters | P1 = x<br>P2 = x<br>P3 = x<br>P4 = xx<br>P5 = xxxxx<br>P6 = xxxxx<br>P7 = x<br>P8 = x<br>P9 = x |
| TD | Transmit Display Menu Parameters | D = xxxxxx*<br>I = xxxxxx*<br>PK = xxxxxx*<br>VY = xxxxxx*<br>S1 = xxxxxx<br>H1 = xxxxxx<br>S2 = xxxxxx<br>H2 = xxxxxx<br>M = xxxxxx<br>B = xxxxxx<br>AM = xxxxxx<br>AB = xxxxxx |

*Transmits "XXXXX" for underbars (out of range, low), "YYYYY" for overbars (out of range, high) and five equal signs "=====" for double bar condition.

# 5 PRINCIPLES OF OPERATION

## 5.1 INTRODUCTION

The AN2406 can be configured to measure temperature using an RTD or Thermistor input device. The configuration is determined by user-selectable jumpers and set-up parameters. The input is digitized and displayed in degrees °F or °C. Software controls allow you to make adjustments on the front panel keypad that affect the output functions of the meter. Various control and communication options can be applied to this meter to maximize its performance. A functional block diagram of the AN2406 is shown in Figure 5-1.

## 5.2 FUNCTIONAL ELEMENTS

### 5.2.1 Input Conditioning

Input signals are filtered before reaching the multiplexer to prevent excessive ac noise from entering the meter. An offset adjustment input shorts the signal inputs to the differential amplifier to allow a zero reading by the A/D converter.

### 5.2.2 A/D Converter

The AN2406 uses Analogic's "Successively Summed Integration" (SSI) technique which provides a 19-bit resolution and better than 0.01% accuracy at 20 conversions per second. Each conversion takes place over three line cycles of 50/60 Hertz. Actual integration of the input occurs over two of those cycles. When in an RS232 transmit mode, conversions take place over a period of five line cycles. The SSI A/D converter is directly controlled by a custom microprocessor chip that also performs most of the other functions of the meter.

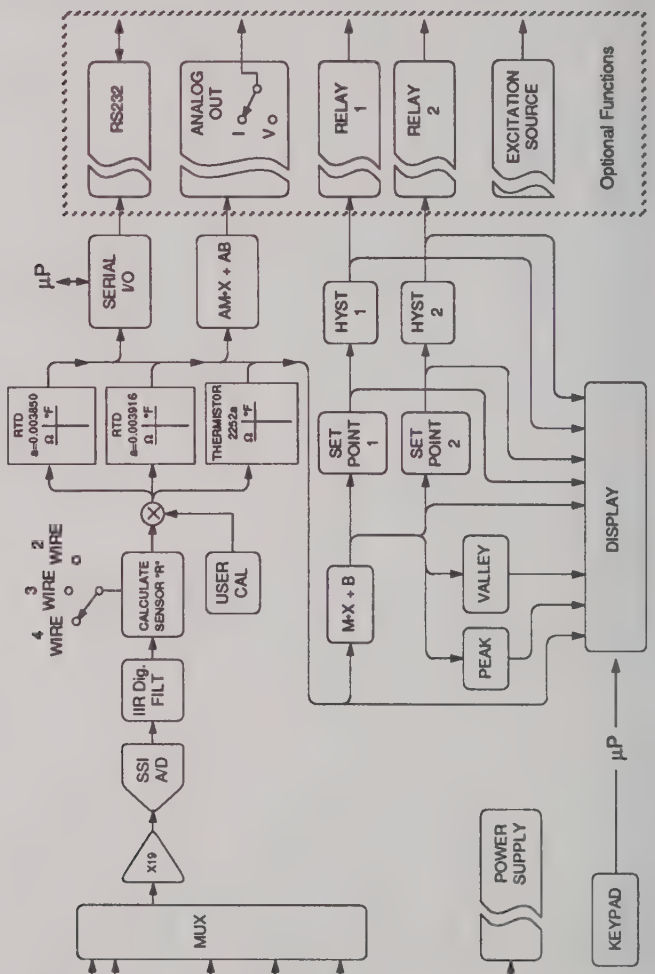



Figure 5-1. AN2406 Functional Block Diagram

### 5.2.3 Digital Filter

This is an Infinite Impulse Response (IIR) filter. The microprocessor applies the IIR filter with a sample group selection of 16 to all inputs: reference, ground and signal input. When a change in the filter input is greater than 256 raw A/D counts, the meter flushes the filter data and a new averaging begins with that new signal conversion.

### 5.2.4 Microprocessor

The microprocessor (μP) selects the proper input, controls the A/D conversion process, mathematically processes the data, drives the display, generates the output signals and monitors the keypad. The operating program is contained in a one-time programmable memory (ROM) inside the microprocessor and a non-volatile memory chip stores operating values and constants when power is removed.

### 5.2.5 Display

All Champion Series panel meters use a green vacuum fluorescent display assembly which is directly driven and controlled by the microprocessor. This assembly has five numerical characters of 15 segments each and can display any number from –19999 to 99999. Between each character there are four decimal points which can be displayed individually. On the far left and right of the five characters there is a signal bar pair used to indicate various operating conditions.

### 5.2.6 Keypad

A six-key keypad provides the user interface to the microprocessor. It allows you to select display modes and enter operating parameters.

## 5.3 OPTIONAL FUNCTIONS

Optional functions that are available for the AN2406 include digital outputs, analog output, RS232 communications and an excitation source. Two digital outputs are provided by two microprocessor-controlled Form C relays (RELAY 1 and RELAY 2). The setpoints, initial conditions, resets and hysteresis are accessible via the keypad. The optional analog circuit can produce an output of 0 to 20 milliamperes or 0 to 10 volts.

Although you choose the scale, the actual output is controlled by the microprocessor. A standard RS232 interface circuit provides serial I/O data communications with a terminal or host computer. The excitation supply provides a current source at jumper-selectable voltages. The output is electrically isolated from the meter by a transformer.

## 5.4 USER-PROGRAMMABLE CONTROLS

### 5.4.1 Display Scaling

The displayed value may be scaled using the algebraic expression of "MX + B", where M is a multiplier, X is the unscaled input and B is an offset value. The operating instructions section of this manual describes how to calculate M and B for your application. The entered values for M and B are stored in non-volatile memory.

The Analog Output option is also scaleable using a similar expression, "AMX + AB, where X is the raw analog output, AM is the analog output multiplier and AB is an offset value.

### 5.4.2 Peak/Valley Monitoring

During normal operation, the Peak and Valley functions record the highest and lowest measurements made by the meter since the last time you reset either function. Each function can be reset independently of the other. Resetting the function clears the previously recorded value.

### 5.4.3 Set Points and Hysteresis

The Set Points and Hysteresis functions are used with the optional dual relay outputs. A Set Point is the displayed value which causes the relay to trip. Set Point values can be from –19999 to 99999. Hysteresis is a deadband amount which causes the related Set Point to untrip the relay. Hysteresis values can be from 0 to 409.

# 6 SERVICE AND SUPPORT

## 6.1 TROUBLESHOOTING GUIDE

The troubleshooting guide in Table 6-1 is designed to help you solve some minor technical problems that may occur during operation. If you need to remove the meter from its case while troubleshooting, remember that the panel meter requires special handling due to static-sensitive devices (see Section 2.3).

**Table 6-1. Troubleshooting Guide**

| Problem | Possible Cause | Recommended Action |
|---|---|---|
| No Display. | (1) Power source off.<br>(2) Loose power connections.<br>(3) Wrong power connections.<br>(4) Power supply failure. | (1) Check power source.<br>(2) See Section 2.8 & 2.9.<br>(3) See Section 2.8 & 2.9.<br>(4) Contact authorized service center. |
| Wrong or unexpected value displayed. | (1) Wrong input connections.<br>(2) Wrong value for M or B.<br>(3) Wrong range jumper position.<br>(4) Wrong Set-Up parameter values.<br>(5) Component failure. | (1) See Section 2.8 & 2.9.<br>(2) See Section 4.6<br>(3) See Section 2.5.<br>(4) See Section 4.7<br>(5) Contact authorized service center. |
| Relays not working. | (1) Wrong signal connections.<br>(2) Wrong setpoint value.<br>(3) Wrong Set-Up parameter values.<br>(4) Option board failure. | (1) See Section 2.8 & 2.9<br>(2) See Section 4.6.<br>(3) See Section 4.7.<br>(4) Repair or replace option board. |
| Wrong or no Analog Output. | (1) Wrong connections.<br>(2) Wrong value for AM or Ab.<br>(3) Option board failure. | (1) See Section 2.8 & 2.9.<br>(2) See Section 4.6 & 4.9.<br>(3) Repair or replace option board. |
| No communication via RS232 interface. | (1) Wrong connections.<br>(2) Mismatched baud rate, parity or word length.<br>(3) Using incorrect commands.<br>(4) Option board failure. | (1) See Section 2.8 & 2.9<br>(2) See Section 4.11.<br>(3) See Section 4.11.<br>(4) Repair or replace option board. |

## 6.2 SERVICE AND TECHNICAL SUPPORT

If your AN2406 panel meter fails to operate upon arrival, contact your dealer or the Measurement and Control Division (MCD) Order Entry service at Analogic's factory in Peabody, MA 01960 to arrange for an exchange. Upon contacting MCD Order Entry, you will be given a Return Material Authorization (RMA) number.

To arrange for an exchange or to get technical assisstance:

Tel: (508) 977-3000

To arrange for service, contact the Customer Service Office:

In the continental U.S.A.:

| | | |
|---|---|---|
| Tel. | (508) 977-3000 | Spare Parts: X3617, X3614<br>Repairs: X3612, X3613 |
| TELEX | 681-7288 anal uw | |
| FAX | (508) 532-8913 | |

| | | |
|---|---|---|
| International: | Analogic GmbH | Tel. 49-6122-70060 |
| | Analogic Ltd | Tel. 44-3-44-860111 |

Before contacting the Customer Service Office, make sure you have the model and serial number, quantity being returned, description of the malfunction, your "Bill To" and "Ship To" addresses and Purchase Order number.

Upon contacting the Customer Service Office, the Service Coordinator will give you a customer service order number (CSO), the warranty status of the units being returned, and the repair charge, if any. The CSO number is your authorization number. Please write this number on your purchase order and shipping label.

Send all authorized returns to:

Analogic Corporation
8 Centennial Drive
Peabody, MA 01960
Attn: Receiving Dock B
CSO# _____

After the material has been returned, you will receive an acknowledgement copy of the CSO which will be marked with the scheduled return date.

# APPENDIX A SPECIFICATIONS

## A.1 PERFORMANCE SPECIFICATIONS

**Input Temperature Ranges:**

| | |
|---|---|
| European Curve, 100Ω at 0 °C, Platinum RTD with temperature coefficient (alpha) of +0.003850 Ω per Ω/°C. | – 342.47 °F to +1590.78 °F<br>– 208.04 °C to +865.99 °C<br>15.00 Ω to 394.92 Ω |
| American Curve, 100Ω at 0 °C, Platinum RTD with temperature coefficient (alpha) of +0.003916 Ω per Ω/°C. | – 336.64 °F to +1560.06 °F<br>– 204.80 °C to +848.92 °C<br>15.00 Ω to 394.92 Ω |
| Thermistor Curve, 2252Ω at + 25 °C. | – 40 °F to +302 °F<br>– 40 °C to +150 °C<br>75780 Ω to 41.73 Ω |
| Cryogenic Curve, 100Ω at 0 °C, Platinum RTD with temperature coefficient (alpha) of +0.003850 Ω per Ω/°C (Option). | – 420 °F to +34 °F<br>– 251 °C to +1 °C<br>2.4 Ω to 100.4 Ω |

**Input Bias Current:**
Sensor High Input: – 500nA ± 10% for open circuit detection
Sensor Low Input: –500nA ± 10% for open circuit detection

**Input Impedance:** 10MΩ ± 10% shunted with 30K + 1μF

**Input Filtering:** Type: 1-Pole, RC Filter
Cutoff Frequency: 5.3Hz ±10%
Settling Time: 305ms (max) to 0.01%

**Absolute Maximum Input Voltage:** –12V dc to +5V dc

**Sensor Excitation:**
For RTD: 2.50 V ± 0.2% in series with 4.99KΩ ± 0.1%
For Thermistor: 203.25 mV ± 0.4% in series with 918.7Ω ± 0.1%

**Normal Mode Rejection (Signal Input to Meter Gnd):**
Input Filter: 20dB (typ) for f ≥ 50Hz
A/D Integration Rejection: 40dB (typ) at selected 50/60Hz line frequency
Digital Filter (16-conversion average): 12dB (typical) for f ≥ 5Hz and conversion-to-conversion difference < 256 raw A/D counts (162μV).
Total NMR: 72dB (typical), 60dB (mim)

**Normal Mode Signal at selected 50/60Hz line frequency:**
50mV p-p (max) (signal input to meter gnd)

**Common Mode Rejection (earth gnd to meter gnd with 1KΩ imbalance):**
CMR Intrinsic: 70dB (typ), 60dB (min) at selected 50/60Hz line frequency.
CMRI increases by 10dB when RS232 and/or Excitation and/or Analog Output options are not used.
Total CMR (CMRI + NMR): 140dB (typ), 120dB (min) at selected 50/60Hz line frequency.

**Common Mode Voltage:**
(earth gnd to meter gnd with 1kΩ imbalance) 354 V dc or peak ac

**Temperature Accuracy:**
Maximum total reading error at +23 °C meter ambient.

| | |
|---|---|
| 100 Ω RTD, Alpha = 0.003850 | – 328 °F to +1562 °F: ± (0.36 + 0.036) °F<br>–200 °C to +850 °C: ± (0.2 + 0.02) °C |
| 100 Ω RTD, Alpha = 0.003916 | –328 °F to 1560 °F: ± (0.36 + 0.036) °F<br>–200 °C to +848 °C: ± (0.2 + 0.02) °C |
| 2252 Ω Thermistor | – 40 °F to 302 °F: ± (0.36 + 0.09) °F<br>– 40 °C to +150 °C: ± (0.2 + 0.05) °C<br>Except:<br>– 40 °F to – 29 °F and<br>+293 °F to +302 °F: ± (0.36 + 0.90) °F<br>– 40 °C to – 34 °C and<br>+145 °C to +150 °C: ±(0.20 + 0.50) °C |
| Cryogenic 100 Ω RTD,<br>Alpha = 0.003850 (Option) | – 418 °F to +59 °F: ± (0.36 + 0.036) °F<br>–250 °C to +15 °C: ± (0.2 + 0.02) °C<br>Except:<br>– 418 °F to – 328 °F: ± (0.36 + 0.45) °F<br>– 250 °C to – 200 °C: ± (0.20 + 0.25) °C |

**Zero Drift:** ± 1 ppm of range/°C (max) of change in meter ambient, all ranges

**Gain Drift:** Thermistor Range: ± 50 ppm of range/°C (max) of change in meter ambient
RTD Ranges: ± 20 ppm of (reading in°C +273.15) or (reading in °F + 459.67)/°C of change in meter ambient, maximum.

**Long term drift:** ± 150 ppm of range/year (max) on all ranges

**Display Error:** ± 1 display count

**Noise:**

| | |
|---|---|
| 100 Ω RTD,<br>Alpha = 0.003850 | 0.009 °F rms (typ), 0.018 °F rms (max)<br>0.005 °C rms (typ), 0.010 °C rms (max) |
| 100 Ω RTD,<br>Alpha = 0.003916 | 0.009 °F rms (typ), 0.018 °F rms (max)<br>0.005 °C rms (typ), 0.010 °C rms (max) |
| 2252 Ω Thermistor | 0.020 °F rms (typ), 0.40 °F rms (max)<br>0.11 °C rms (typ), 0.22 °C rms (max)<br>Noise is reduced by half for every 150 °F (83 °C) decrease from +302 °F (+150 °C) |
| 100 Ω Cryogenic RTD,<br>Alpha = 0.003850 | 100 Ω Cryogenic RTD, Alpha = 0.003850<br>0.035 °F rms (typ), 0.070 °F rms (max)<br>0.019 °C rms (typ), 0.039 °C rms (max) |

**Minimum Display Resolution:**
RTD(All): 0.01 °C, 0.1 °F, Internal Resolution: 0.0033 °C, 0.0060 °F, Typical at 0 °C.
Thermistor: 0.01 °C, 0.1 °F, Internal Resolution: 0.01 °C typical to +90 °C, 0.01 °F typical to 180 °F, 0.08 °C typical to 150 °F, 0.14 °F typical to 302 °F.

**A/D Resolution:** All ranges 634 nV (typ), 330,000 counts (typ) from 0 to + 210 mV. Internal range of _ 19 mV to + 235 mV (typ).

**Warm-Up Time:** 30 minutes, repeatability: ± 1 display count

**Power Line Rejection Ratio:** (change in power line voltage to display change at 2 µV/count for 0.01 °C/count, RTD): 130dB (min), 150dB (typ)

**Open Sensor Indication:**
Open Sensor High: Meter drifts high, out of range in less than 1 second.
Open Sensor Low: Meter drifts low, out of range in less than 1 second.
Open Sensor Excitation: Meter goes out of range in one reading (typ).
Open Meter Ground: Meter goes out of range in one reading (typ).

## A.2 GENERAL SPECIFICATIONS

**External Dimensions (Includes backplane and screw terminals):**
48mm (1.89in) H x 96mm (3.78in) W x 162mm (6.38in) D

**Weight:**
AC Unit = 0.55kg (1.2lb) max. [0.64kg (1.4lb) max., fully-loaded]
DC Unit = 0.36kg (0.8lb) max. [0.45kg (1.0lb) max., fully loaded]

**Construction Materials:**
Black ABS plastic case, grey, anti-glare polycarbonate display filter, grey silicone rubber keypad.

**Panel Cutout Dimensions:** 1/8 DIN , 45mm (1.77in) X 92mm (3.62in)

**Input Power:**
93.5 to 132 Vac, 47-63 Hz, 187 to 264 Vac, 47-63 Hz, or 8 to 28 Vdc

**Power Dissipation:**
AC – 4.0W (Standard) / 8.5W (Fully-loaded) Maximum
DC – 3.0W (Standard) / 5W (Fully-loaded) Maximum

**Isolation:**
AC - 354 V peak, 1500V Hipot Tested; DC - 354 V, 1000V Hipot Tested
Meter circuits isolated from AC power by a transformer. Optional Analog outputs isolated by optical couplers. Digital relays isolated by relay coils.

**DC Operating Temperature:** 0 to 60°C (Standard) / 0 to 50°C (Fully-loaded)

**AC Operating Temperature:**
Standard: 0 to +T, T = 55°C at $V_{line}$ = 110/220 minus 0.25°C/%$V_{line}$
Fully Loaded: T = 37°C at $V_{line}$ = 110/220 minus 0.55°C/%$V_{line}$
With Dual Relays: Derate T by – 4°C at $V_{line}$ minus 0.07°C/%$V_{line}$
With Analog Output: Derate T by – 6°C at $V_{line}$ minus 0.09°C/%$V_{line}$
With RS232: Derate T by – 3°C at $V_{line}$ minus 0.05°C/%$V_{line}$
With Excitation: Derate T by – 5°C at $V_{line}$ minus 0.09°C/%$V_{line}$

**Storage Temperature:** –55 to 80°C

**Humidity:** 0 to 90% Non-Condensing

**Surge Withstand:** Wave Frequency: 1.0 to 1.5 MHz
Crest Value (first half cycle): 100V
Envelope Decay: 50% in 6µsec
Source Impedance: 150 Ohms

**EMI/RFI Emissions:** Meets FCC class A for conducted and radiated emisions

**Vibration:** Meets IEC 68-2-36

**Meets the following safety requirements:**
IEC 66E – March 1986, IEC 742 – 1983, UL 1244 – May 1987, UL 508 – August 1984, CSA-C22.2 #66 – 1988, CSA-C22.2 #231 – M89

## A.3 OPTIONS SPECIFIATIONS

**Digital Outputs:**
Type: Two, Dual Form "C" relays
Connections: Normally open, arm or common and normally closed.
Switched Current: 10 µA (min.), 1 A (max.)
Switched Voltage: 50 µV (min.), 120 V dc or peak ac (max.)
Switched Power: 25 µW (min.), 24 Watts (max).
Minimum Switching Operations: 12,000,000 divided by the switched power in Watts (max. of 20,000,000)
Isolation: 354 V peak ac or dc.

**Analog Output:**
Output Modes: Voltage or current, jumper selectable
Signal Source: 12-bit serial input DAC, resolution of 1:3906 (000H to F42H) or 0.026% of fullscale range (limited by resolution of display)
Voltage Range: 0 to 10 volts with source resistance of 500 ohms ± 0.1%
Current Range: 0 to 20 mA with source compliance of 0 to 10 V
Accuracy: ± 0.04% of range, ± 0.020% of output
Linearity: 0.05% of range
Temperature Drift: ± 0.02% of range per °C
Response (10% to 90%): 150 µsec (max.)
Full Scale Analog: 20000 counts (AM x Display + Ab)
Isolation: 50 V peak ac or dc
Absolute Maximum Output: 10.48 Vdc (FFF Hex), output is linear up to this absolute value

**RS232 Interface:**
9600 Baud, No Parity, 1 Start Bit, 7 Data Bits, 2 Stop Bits

**Excitation Output:**
Voltages: 12 V ± 5%, 24 V ± 5%, jumper selectable
Excitation Current: 24 mA, max
Line Regulation: 0.1% for 10% change in line voltage
Load Regulation: ± 1.5% of excitation from no load to full load
Isolation: 354 ac peak or dc

# APPENDIX B
# ORDERING INFORMATION

## ORDERING DETAILS

To place an order, determine the model number using the ordering guide on the next page and contact Analogic Corporation, Peabody, MA or your nearest Analogic sales office or representative.

*In the continental U.S.A.:*

| | | |
|---|---|---|
| Telephone | | (508) 977-3000, X3871 or X3879 |
| Telex | | 681-7180 |
| FAX | Order Entry | (508) 532-6097, or |
| | Sales | (508) 531-1266 |

*International:*

| | |
|---|---|
| Analogic GmbH | Telephone 49-6122-70060 |
| Analogic Ltd | Telephone 44-3-44-860111 |

The ANSC3 edge connector is included with all models except the AN2402. The AN2402 includes the ANTC2-TC screw terminal type backplane connector.

Options and accessories may be ordered separately. To determine the model number of an option, add the suffix of the corresponding option from the ordering guide to the model number "AN24_". For example, to order a Dual Relay Card for the AN2400, AN2402 or AN2406, specify model number "AN24E".

## CHAMPION SERIES ORDERING GUIDE

| | Input | Power | Case | Options |
|---|---|---|---|---|
| Model AN240 | [ ] – | [ ] – | [ ] – | [ ] |

**Input:**
0 = DC Voltage/Current
1 = Strain/Pressure/Weight
2 = Thermocouple
3 = RTD/Thermistor

**Power:**
1 = 110 Volts AC
2 = 220 Volts AC
3 = 8 - 2 Volts DC

**Case:**
0 = Standard Case

**Options:**

| | | | | |
|---|---|---|---|---|
| X = | No Options | | | |
| A = | Dual Relays | | | RS232 |
| B = | Dual Relays | Analog Out | | RS232 |
| C = | | Analog Out | | RS232 |
| D = | | | | RS232 |
| E = | Dual Relays | | | |
| G = | | Analog Out | | |
| H = | Dual Relays | Analog Out | | |
| X1 = | | | Excitation | |
| XE = | Dual Relays | | Excitation | |
| XA = | Dual Relays | | Excitation | RS232 |
| XD = | Dual Relays | | Excitation | |
| XG = | | Analog Out | Excitation | |
| XH = | Dual Relays | Analog Out | Excitation | |
| *AN2401 Only:* | | | | |
| SA = | Dual Relays | | Excitation | RS232 |
| SD = | | | Excitation | RS232 |
| SE = | Dual Relays | | Excitation | |
| SG = | | Analog Out | Excitation | |
| SH = | Dual Relays | Analog Out | Excitation | |

**Accessories:**

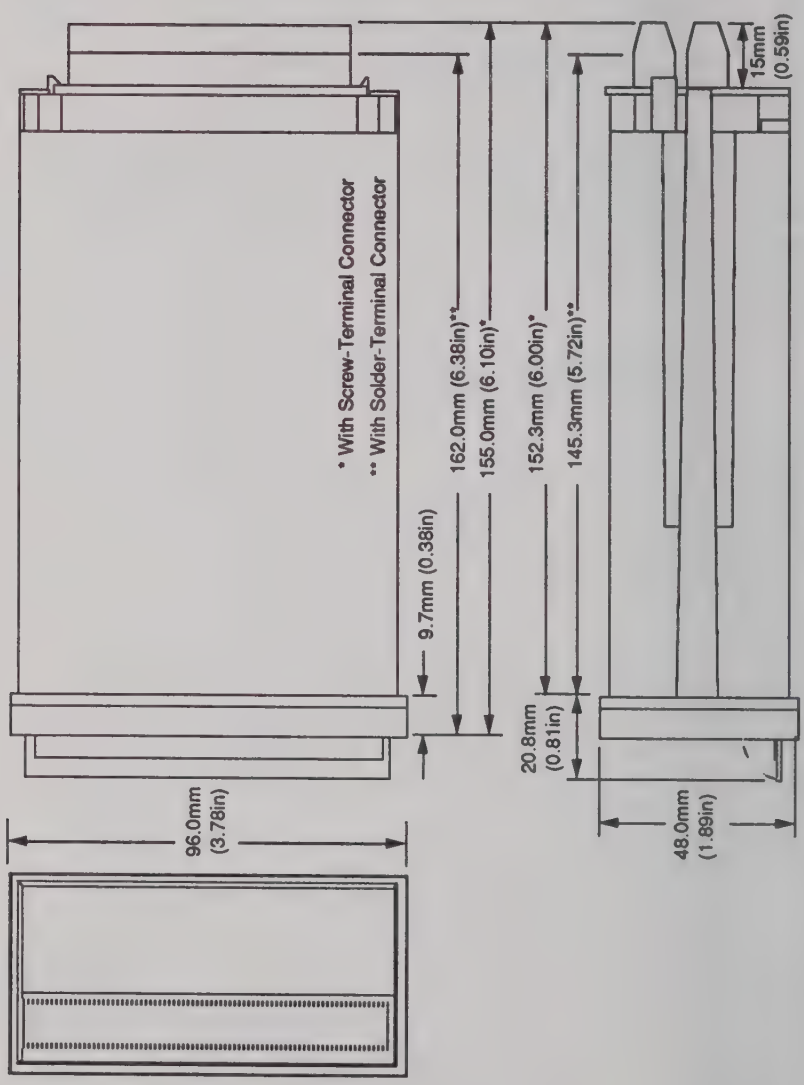
| Model No. | Description |
|---|---|
| ANSC3 | Solder Terminal Connector |
| ANTC2 | Terminal Block Backplane Connector |

# APPENDIC C
# MECHANICAL DRAWING

This appendix contains a mechanical drawing of the panel meter showing the overall physical dimensions. Note that the length is given for the meter with either the ANSC3 edge connector or the ANTC2 backplane connector.

**NOTE**

The panel meter case mounts in a standard 1/8 DIN panel cutout [45mm (1.77in) x 92mm (3.62in)].


* With Screw-Terminal Connector
** With Solder-Terminal Connector
162.0mm (6.38in)**
155.0mm (6.10in)*
152.3mm (6.00in)*
145.3mm (5.72in)**
15mm (0.59in)
9.7mm (0.38in)
20.8mm (0.81in)
96.0mm (3.78in)
48.0mm (1.89in)

# APPENDIX D REFERENCE

## D.1 TEMPERATURE DEFINITIONS

**Cryogenic:** Very .i.low temperatures;; used in reference to liquified gases such as LOX (-297°F) and LN2 (-320°F). Requires use of high resistance Platinum RTD's (500-5,000 ohms), gold-chromel thermocouples or low temperature thermistors.

**Duplex Sensor:** A dual sensor usually isolated from each other and in the same housing or sheath.

**Freeze Point Std:** Provides known fixed reference temperatures, the freezing points of metals. Usually not monitored by a reference thermometer since pure metal samples are certified.

**Kapton:** A Dupont Company Polymide insulation material; Radiation Resistant, Maximum Temperature 285°C. Used for high temperature lead wire insulation for RTDs and T/Cs.

**Tubing vs. Pipe:** Outside diameter, the proper way to size thermocouple sheath tubing vs. inside diameter used for pipe sizing.

**Response Time:** Time constant of a sensor. The time necessary for the sensor to reach 63.2% of step change in temperature with the sensor in water at a velocity of three (3) Ft/Sec, transverse to the sheath.

**Teflon/Tefzel:** Medium temperature wire insulations useful to 500°F and 390°F respectively. Tefzel has some radiation resistance.

**Thermowell:** The pressure vessel into which a thermocouple is inserted for easy removal and/or replacement purposes.

## D.2 TEMPERATURE STANDARDS

### Freeze Points of Metals*

| | °F | °C |
|---|---|---|
| Tin | 449.55 | 231.97 |
| Lead | 621.50 | 327.50 |
| Zinc | 787.24 | 419.58 |
| Antimony | 1167.33 | 630.74 |
| Aluminum | 1220.67 | 660.37 |
| Silver | 1763.47 | 961.93 |
| Gold | 1947.97 | 1064.43 |
| Copper | 1984.10 | 1084.5 |

* Reference points from IPTS-68

### Standard Temperature Points

| | °F | °C |
|---|---|---|
| Ice Point | 32 | 0 |
| Boiling Point, H2O | 212 | 100 |
| Triple Point, H2O | | 0.01 |

### Cryogenic Gases**

| | Melt Pt. °C | Boil Pt. °C |
|---|---|---|
| Freon | | – 160 |
| Freon | | – 181 |
| Oxygen | – 218.4 | – 183 |
| Argon | – 189.2 | – 185.7 |
| Nitrogen | – 209.9 | – 195.8 |
| Neon | – 248.7 | – 245.9 |
| Hydrogen | – 259.14 | – 252.8 |
| Helium | < – 272 | – 268.94 |
| Absolute Zero | | – 273.15 |

## D.3 STANDARDS ORGANIZATIONS

| | |
|---|---|
| **ANSI** | American National Standards Institute |
| **ASTM** | American Society for Testing & Materials |
| **BS** | British Standards (Nat'l Physical Laboratory - U.K.) |
| **CSA** | Canadian Standards Association |
| **DIN** | Deutsches Institut für Normung (Germany) |
| **IEC** | International Electrotechnical Commission |
| **IPTS** | International Practice Temperature Scale |
| **JIS** | Japanese Industry Standards |
| **NIST** | National Institute of Standards and Technology (United States) (Formerly NBS) |

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